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FINAL REPORT

ORBIT TRANSFER ROCKET ENGINE TECHNOLOGY PROGRAM ENHANCED HEAT TRANSFER COMBUSTOR TECHNOLOGY

By

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FOREWORD

This report documents the results of the third subtask of a program conducted for the NASA Lewis Research Center by Rocketdyne, a division of Rockwell International. Ms. Sybil Huang Morren was the NASA-LeRC Task Manager. At Rocketdyne, Mr. R. P. Pauckert was the Project Manager and Mr. William S. Brown the Project / Development Engineer.

The work was conducted by personnel in the Engineering and Test function of Rocketdyne. Important contributions to this program task were made by:

Ms. L. Davis	Integrated Component Evaluator (I.C.E.) Structural Analysis
Mr. G. Gladman	Integrated Component Evaluator (I.C.E.) Re-Configuration Design
Mr. J. Orr	Integrated Component Evaluator (I.C.E.) Thrust Chamber Transient and Performance Computer Simulation
Mr. S. Fischler and Mr. J. Pulte	Advanced Propulsion Test Facility Test Engineering
Mr. W. Wagner and Mr. J. Carroll	Thermal Analysis

Additional program support was obtained from Messrs. R. D. Baily and H. Dubrick, who provided important and invaluable technical continuity and assistance to the program.

REPORT ORGANIZATION

This report is divided into six sections; introduction, summary, program approach, thrust chamber hardware performance, calorimeter performance, and finally the sixth section discusses the conclusions of the technology task effort. Detail data is contained in the appendices.

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1.0 INTRODUCTION

The thrust chamber combustor of a high performance, advanced expander-cycle engine serves a dual function. First, it performs the function of containing the high pressure combustion process and accelerating the combusted gases to sonic velocity for expansion in the exhaust nozzle, producing thrust. Second, it provides a majority of the energy required to power the propellant turbopumps. In Rocketdyne's oxygen-hydrogen expander cycle engine, the turbopump turbines are powered by hydrogen heated by regenerative cooling of the thrust chamber components. Approximately 75% of the heat input to the hydrogen is derived from the combustor assembly. The remainder is supplied by the regenerative section of the nozzle assembly.

In general, a higher chamber pressure leads to higher engine performance due to improved expansion properties of the combustion gases. Higher chamber pressures also reduce engine size and weight for similar thrust levels.

Combustor thermal performance has a central role in determining the overall performance of the advanced expander cycle engine. Therefore, developing the technologies for enhancing combustor heat extraction and service life performance is crucial to meeting the goals of the advanced expander cycle engine technology program. Subsequently, the first portion of the Enhanced Heat Transfer Technology program dealt with various methods of increasing heat extraction. Two-D hot and cold flow experiments were conducted to: screen various combustor rib geometries, evaluate flow characteristics of candidate ribs, and compare the designs at hot-fire conditions. The results of 2-D testing indicated that a 0.040 in. rib configuration would be the optimum for enhancing heat transfer to the combustor. The total heat load enhancement, based on 2-D test data, of a full size combustor with a 16 in. barrel section was 42%. These findings are detailed in the Interim Report for the Orbit Transfer Rocket Engine Technology Program, entitled Enhanced Heat Transfer Combustor Technology, Task C.1 Subtasks I and II, under contract NAS3-23773.

The tasks covered in this report deal with applying the technology gained in the previous tasks and evaluating the optimum configurations in a hot-fire environment. Calorimeter combustors were fabricated and tested to determine the heat transfer enhancement effects of hot-gas wall ribs. The results of those tests were extrapolated and projected to full size combustor geometries where a direct comparison to the 2-d test results could be made. From this an evaluation could be made as to the overall enhancement capability of hot-gas wall ribs.

2.0 SUMMARY

In order to increase chamber pressure which increases engine performance, more heat energy needs to be extracted to drive the turbomachinery. The increased heat energy maximizes the efficiency of the turbomachinery operation and reduces the size and weight of the engine. In the past, the heat energy requirements of the turbopumps required longer combustion chambers. Size limitations created the need for a different method to increase heat extraction. This requirement was fulfilled by increasing the area exposed to the hot-gas by using combustor ribs. The ribs increased the total area exposed to the hot-gas by 80%, and thus increased the enthalpy in the coolant working fluid. To substantiate this theory, two-dimensional hot and cold flow experiments were conducted to determine an optimum rib height. The results indicated that a 0.040 in. rib height would be the optimum configuration for enhancing heat transfer to the combustor. A combustor calorimeter was fabricated to determine the enhancement of hot gas wall ribs. An existing Integrated Component Evaluator (I.C.E.) thrust chamber assembly was modified to accept the calorimeter and installed into the NAN-test stand position at the Advanced Test Propulsion Facility of Rocketdyne's Santa Susana Field Laboratory.

The 0.040 in. ribbed calorimeter combustor completed a total of four steady-state tests both in a ribbed and a smooth wall combustor configuration. The tests were conducted at ~850 and ~1050 psia chamber pressures with mixture ratio excursion sweeps between 5.0 and 7.0. The heat transfer results from the ribbed calorimeter 830 psia Pc test indicated that the mixture ratio excursions affected heat loads significantly. The mixture ratio varied from 4.0 to 5.6 and increased heat loading approximately 1.92 Btu/in^2-sec. per 1.0 (O/F) mixture ratio change. The heat transfer data from the 830 psia and 1050 psia Pc tests showed an increased heat load rate with increasing Pc, while the heat rate profiles, as a function of length from the injector, were similar. The 850 psia Pc test, at a mixture ratio of 5.6, showed a 50% enhancement over a smooth wall. The 1050 psia Pc test, at a mixture ratio of 4.7, showed a 40% enhancement over a smooth wall. Normalizing the mixture ratio revealed the enhancement was greater for the 1050 psia Pc test than for the 850 psia Pc test. This indicates that the rib heat transfer enhancement factor is sensitive to changes in mixture ratio as well as chamber pressure.

The projected enhancement from the ribs for a 16 in. long cylindrical combustor at 15Klb$_f$ nominal thrust level, is a 58% increase in heat transfer rate, which translates to a 46% increase for a full size 15Klb$_f$ combustor. The combustor test results show that the ribs are as effective as previous analysis and 2-d subscale testing indicated. They also showed that higher mixture ratios and chamber pressures can increase the effectiveness of 0.040 in. ribs.

3.0 PROGRAM OBJECTIVES AND APPROACH

The primary objective of this task was to characterize the heat load enhancement capabilities of the 0.040 in. ribbed combustor. A secondary objective was to determine the effects of mixture ratio changes on that enhancement during hot-fire testing. Two hot-fire test series were conducted using two calorimeter configurations, ribbed and smooth wall. The program used the Integrated Component Evaluator (I.C.E.), Figure 3-1, re-configured into a thrust-chamber-only mode, i.e. no turbopumps were used in the system. Specific goals were to verify increase in heat transfer to the working fluid by the ribs as predicted in hot-air gas and cold flow 2-d tests, subtasks I and II of Tasks C.1 and C.2.

Three technical subtasks were identified to accomplish program objectives. These subtasks are listed below:

Enhanced Heat Transfer Combustor Technology Subtasks

I. Heat Load Maximization Studies (Hot-Gas Wall Ribs)
   - Hot-Air Panel Chamber Tests
   - Cold Flow Boundary Layer Mapping Tests

II. Increased Life Studies (Coolant Channel Enhancements)
   - Cold Flow Boundary Layer Mapping Tests

III. Calorimeter Insert Hot-Fire Tests
   - High Pc Tests of Optimum Configurations
   - Evaluate Results and Determine Optimum Rib Configuration

Subtasks I and II were completed and are documented in NASA Report No. CR179541, 16 December 1986, Enhanced Heat Transfer Combustor Technology Task C.1, R.D. Baily. Subtask III is described and contained within this report.

Task III required the fabrication and hot-fire test of a calorimeter combustor with the optimum rib height. The results of 2-d testing indicated that a 0.040 in. rib configuration would be the optimum for enhancing heat transfer to the combustor. The total heat load enhancement, based on 2-d test data, of a 16 in. barrel section was 58%. Over a full size combustor, including the throat section, it would be 46%. The Subtasks I and II report used a different convergent/divergent section total heat load, resulting in a calculated enhancement of 42%.

The 2-d test results, shown in Figure 3-2, revealed the thermal enhancement was highest for a rib height of 0.04 inches. A 0.040 in. rib height was not expected to erode or melt due to hot-fire. A 6.55 in. long combustor with 11 circumferentially cooled calorimeter circuits was fabricated with 0.040 in. high hot-gas wall ribs, Figure 3-3. The system was installed between the existing injector and the tapered wall combustor of the ICE thrust chamber stack. The program culminated in a hot-fire test series, consisting of system blowdowns, start transient and steady state tests. Two

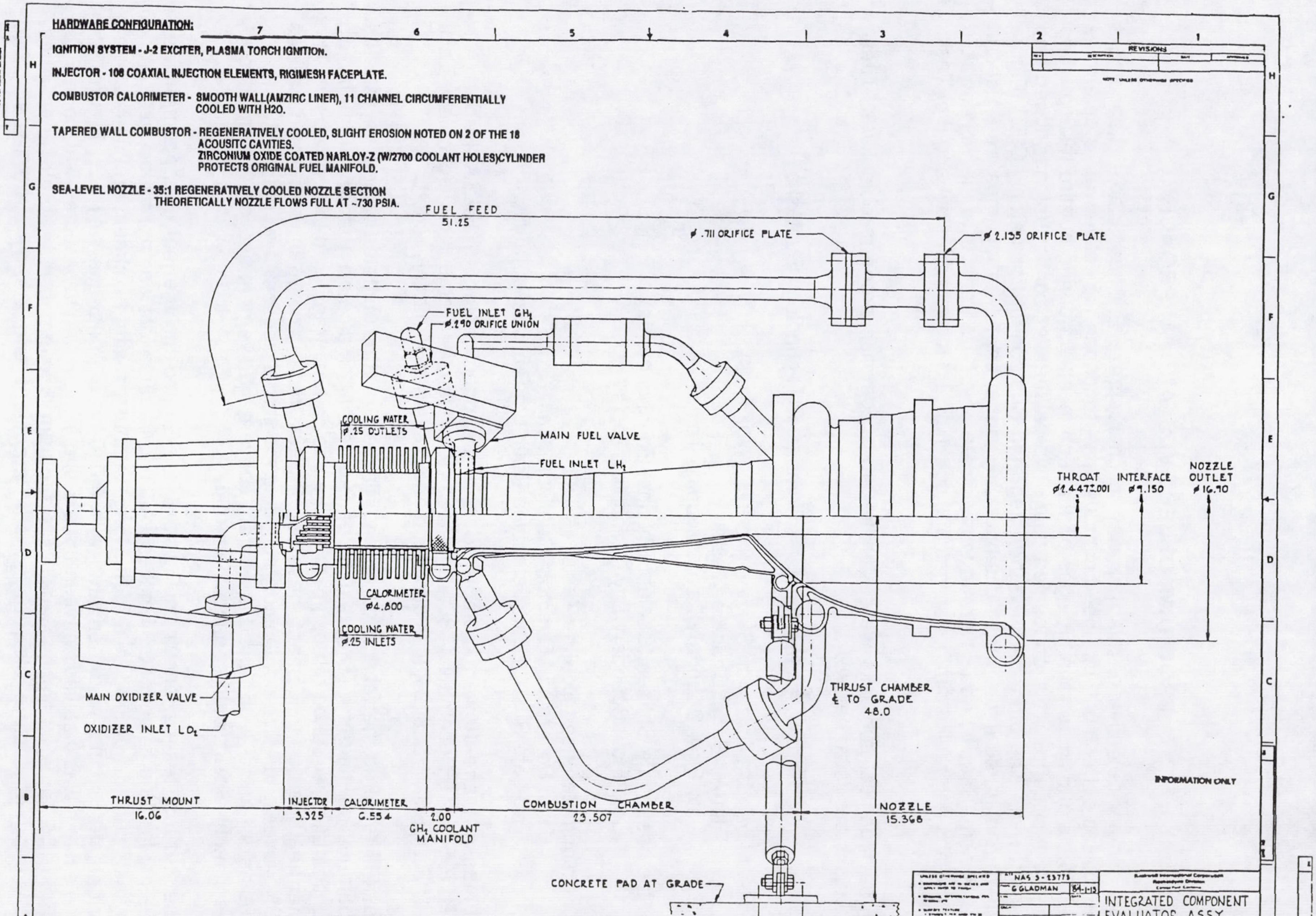

Figure 3-1: Integrated Component Evaluator (I.C.E.) Thrust Chamber Assembly
Enhanced Heat Transfer Combustor Configuration

RIB THERMAL ENHANCEMENT FOR FULL COMBUSTOR BASED ON 2-d TEST RESULTS

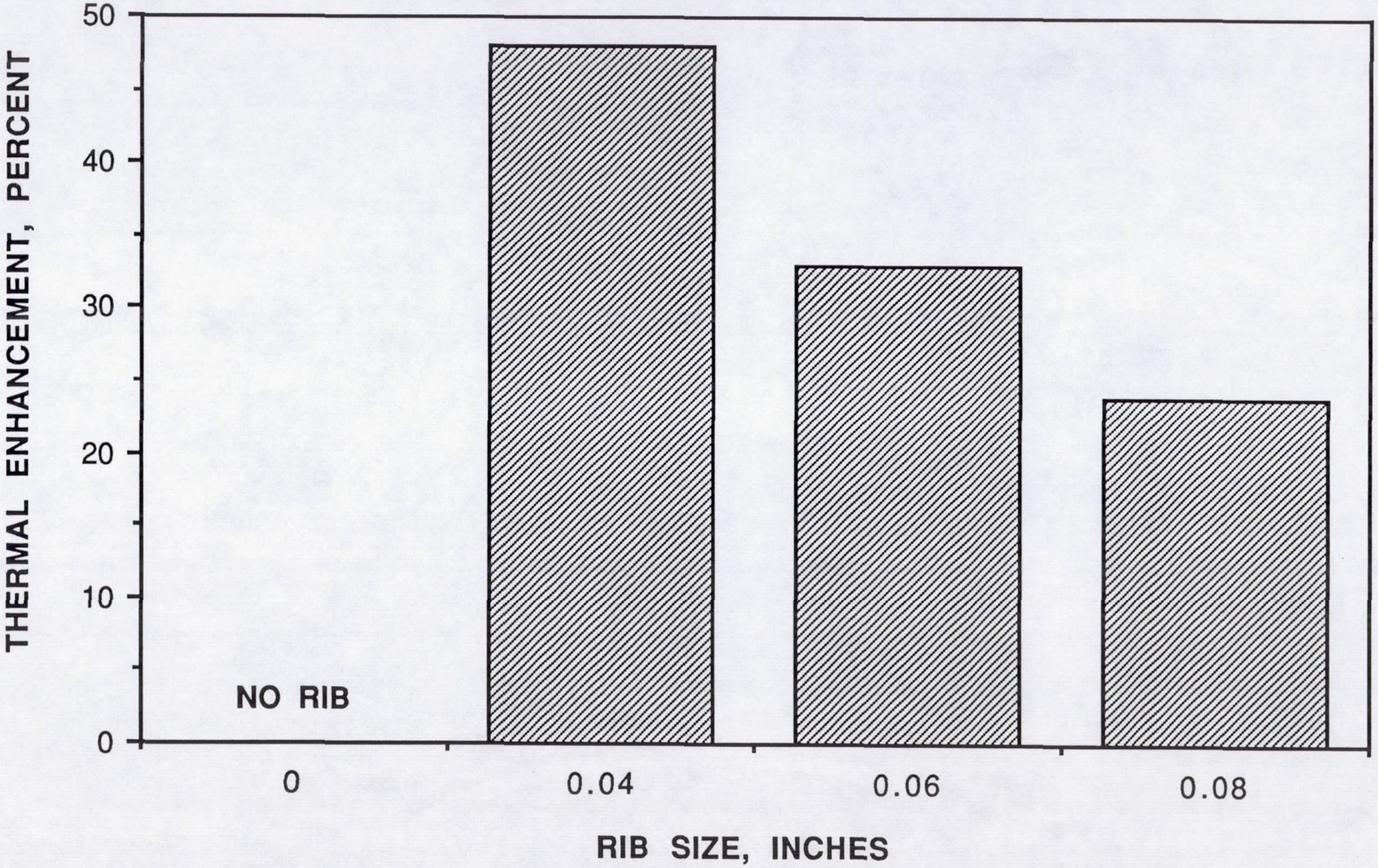

Figure 3-2

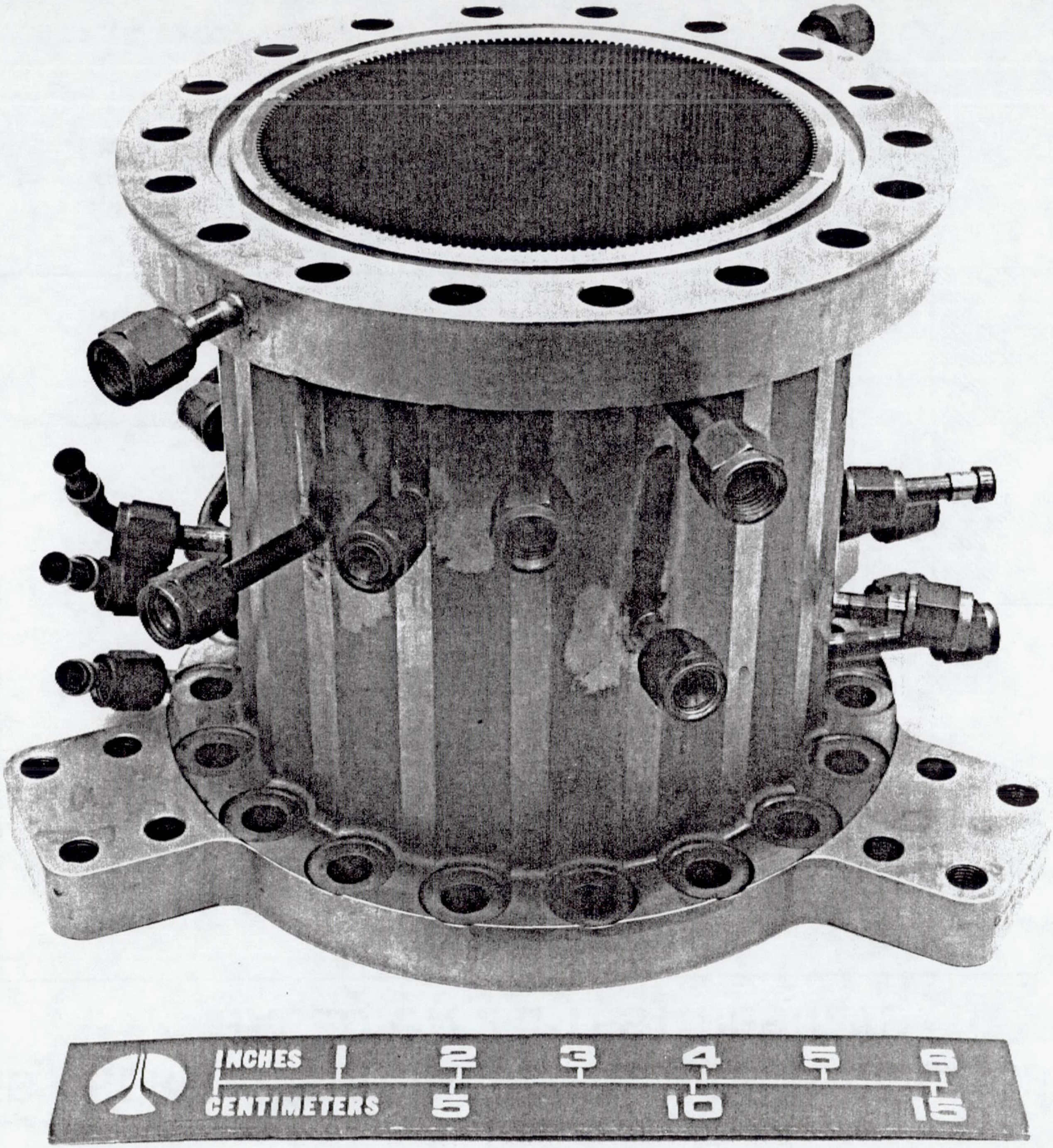

Figure 3-3: 0.040 in. Ribbed Circumferentially Cooled Calorimeter

calorimeter configurations were tested--the 0.04 in. rib configuration and a smooth wall configuration, using the same calorimeter with the ribs removed. During each steady state test the valves were modulated to vary the mixture ratio to at least four different set points. The data were reduced and then extrapolated to both 16 in. barrel and full size combustors. They could then be compared directly to the 2-D flow data.

3.1 TEST HARDWARE and FACILITY DESCRIPTION

The test hardware consisted of the following subsystems: Circumferentially Cooled Calorimeter Combustor, Calorimeter Combustor Coolant Management System, Ignition System, Injector, Tapered Wall Combustor, 35:1 Sea-level Nozzle and the Test Facility Systems. These systems are described in the following sections in detail.

3.1.1 Circumferentially Cooled Calorimeter Combustor - The calorimeter was fabricated from two major components; the liner and the housing (Ref. Dwg. 7R0016277-1). The liner was made from Amzirc, a copper material alloyed with zirconium. The liner outer diameter coolant channels were machined and gold plated. The inner diameter was machined so that the troughs cut at a later assembly stage would create the 0.040 in. ribs. The housing was made from Inconel 625, with the coolant channel side I.D. nickel plated. The liner and housing were brazed together along with the twenty two, 0.25 in. dia. x 0.020 in. wall thickness inlet and outlet tubes. The 0.040 in. hot-gas wall ribs were then machined into the Amzirc liner I.D. using a numerically controlled tungsten-carbide blade and successive longitudinal sweeps (~6 sweeps per rib trough) resulting in the ribs as seen in Figure 3-4.

The calorimeter was proof pressure tested to verify structural integrity and flow calibrated to determine coolant water flow characteristics. The water flow calibration of all eleven circuits indicated that the resistance was almost twice as large as predicted by analysis. The original analytical coolant requirements indicated that an inlet pressure of 2200 psig was needed at a flowrate per channel of 1.81 lbs/sec. The calibration results indicated that the operating inlet pressure would have to be increased to 3000 psig in order to properly cool the calorimeter channels.

Structural analysis of the 0.040 in. ribbed calorimeter liner indicated that the maximum pressure before yield, was 2420 psig. Operating at an inlet pressure of 3000 psig would give a 0.74 factor of safety on yield for the liner, at the worst structural location (assuming minimum material properties). This analysis was conservative in that it assumed only 50% braze joint attachment. Therefore the predicted liner yielding was expected to be minimal and would not affect operation. The analysis also indicated that coolant tube hoop strain was only 0.13 percent (a hoop strain of greater than 2% would have been cause for concern), indicating the calorimeter low cycle fatigue life was in excess of 10^4 cycles. This analysis and the fact that the combustor assembly was proof pressure tested and cycled to 2750 psig, indicated that minimal risk was involved in operating the calorimeter at 3000 psig.

3.1.2 Calorimeter Combustor Coolant Management System - The system used to feed the combustor calorimeters consisted of an inlet manifold which fed the eleven coolant circuits. The flowrate was controlled by flow control orifices located at the exit of the inlet manifold. Water circuited through 1/2 in. dia. tubing (shown in Figure 3-5) to the

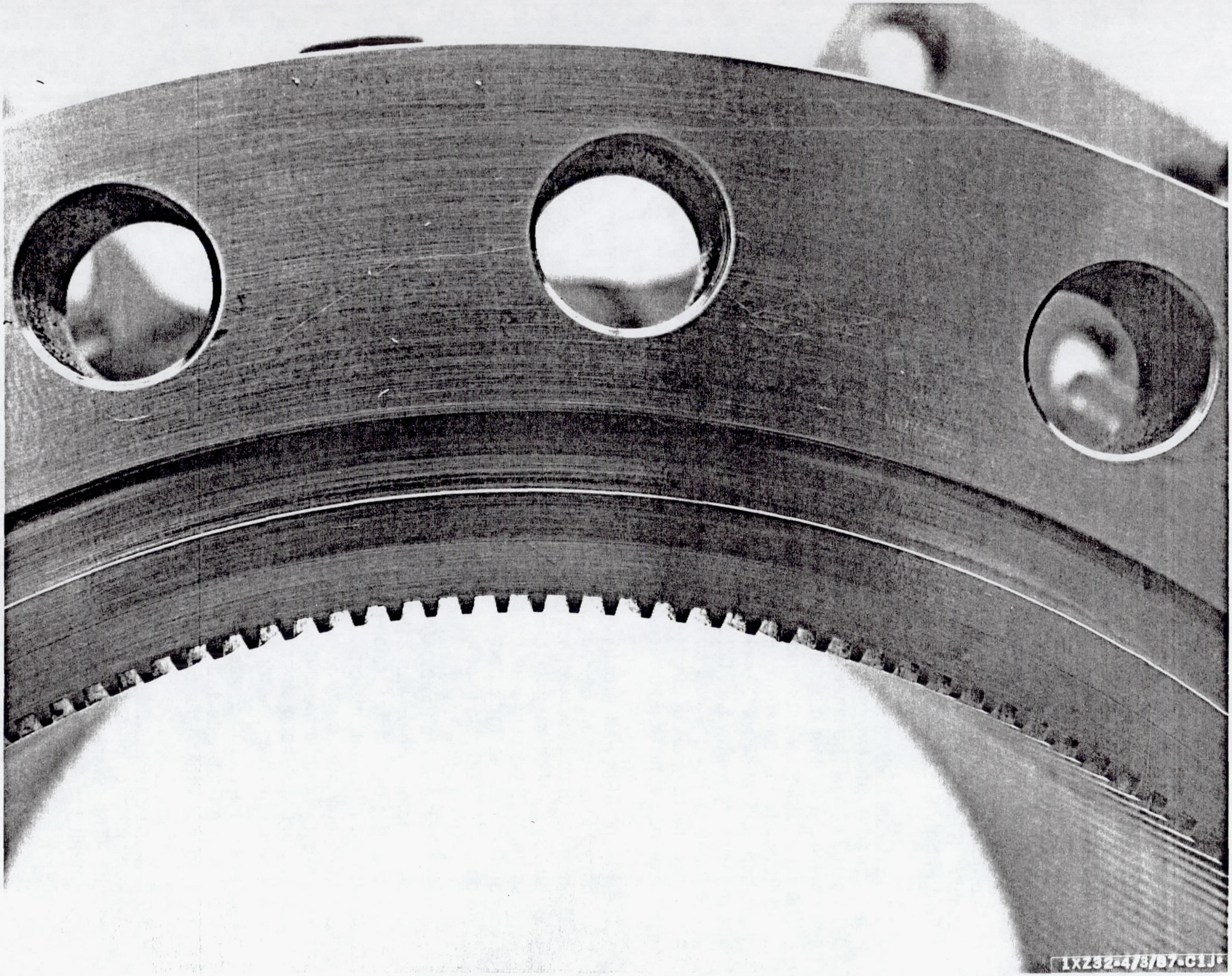

Figure 3-4: Detail of 0.040 in. Machined Ribs

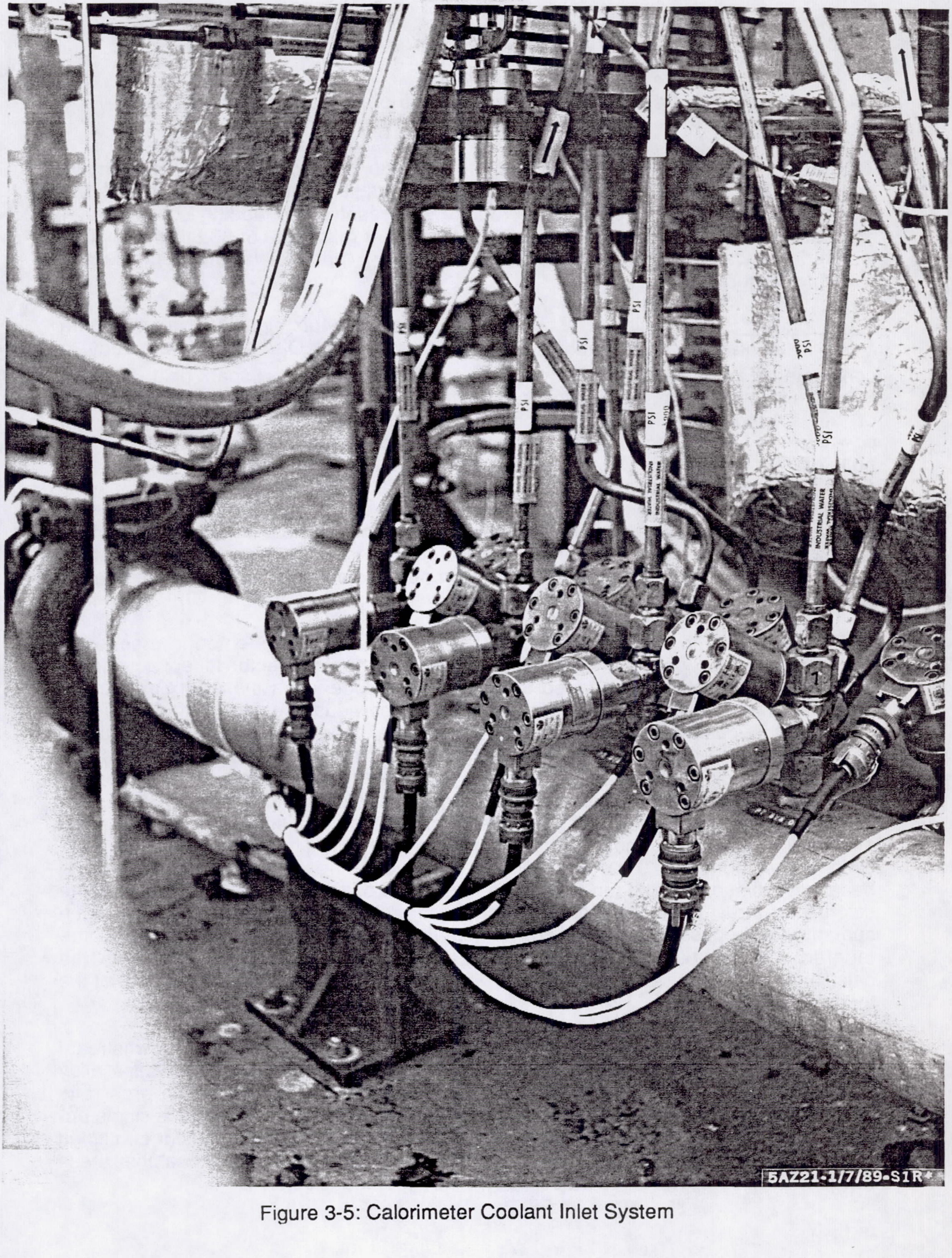

Figure 3-5: Calorimeter Coolant Inlet System

calorimeter and left the calorimeter at an average pressure and temperature of 1500 psig and 300 deg. F.

The coolant water was then passed through 1/4 in. dia. lines to an exit manifold, shown in Figure 3-6. Any flashing or boiling would result in improper cooling of the calorimeter channels. The flashing problem was resolved by adding coolant water from the inlet manifold directly into the exit manifold at a flowrate of 33.8 lbs/sec. This lowered the water temperature to below 116 deg. F prior to flowing from the exit manifold, Figure 3-7.

3.1.3 Ignition System - The I.C.E. system used a plasma-torch ignition system, Figure 3-8a. The plasma torch igniter element consists of an O_2/H_2 injection body, a combustor/nozzle for ducting the hot gas to the combustor, and a spark plug. Oxygen is injected from an annular manifold around the spark plug electrode. A small amount of fuel is injected into the igniter combustor/nozzle where it mixes with the oxygen downstream of the electrode, producing oxygen-rich combustion (MR = 40:1). The bulk of the igniter fuel flows around the combustor and flame tube, providing necessary cooling before being discharged at the injector face. A spark plug is attached to the igniter body through a threaded joint and seal. The ignition sequence was developed during an earlier I.C.E. engine test series. The same igniter propellant feed system was plumbed to eliminate ignition sequence variations. Sonic venturis were used to measure and control igniter propellant flowrates. The ignition system spark plug received energy from a J-2 exciter system.

3.1.4 Injector - The injector consists of 108 coaxial elements oriented in a series of concentric circular locations with a Rigimesh porous metal injector faceplate, Figure 3-8b. The elements are arranged to provide a homogeneous mass flux of injected propellants with uniform radial mass distribution. Individual element mixing efficiency is ensured by design features which are based on experience with high performance, gas-liquid coaxial element injectors. A high velocity ratio between the gaseous fuel and the liquid oxidizer provides the high shear forces required for droplet stripping. The injector element is patterned after the injector elements of the SSME main injector, SSME preburners and Advanced Space Engine Injector. The combustion efficiency of this injector configuration is in excess of 99.6%, at nominal thrust levels. Unfortunately further C* data could not be acquired during the thrust chamber testing because 1 lb/sec of hydrogen was being introduced downstream of the injector at the calorimeter-thrust chamber interface to cool and protect this interface. This hydrogen coolant was necessary to protect the original fuel manifold which is welded to the tapered wall combustion chamber. This introduced a substantial error into the calculation of C* as the additional fuel is 1/4 of the total fuel flow and almost 1/6 of the total flow.

3.1.5 Tapered Wall Combustor - The main combustion chamber located downstream of the water cooled calorimeter was a single pass, channel wall, copper base alloy (Narloy-Z) configuration, Figure 3-9. The chamber includes an expansion area ratio downstream of the throat of 14:1. The combustor was hydrogen cooled by a single up-pass circuit with ~ 4.09 lb/sec coolant flow. The head end of the combustor contained acoustic cavities to aid in combustion stability. Due to the calorimeter chamber these acoustic cavities were moved 6.55 in. downstream of the injector.

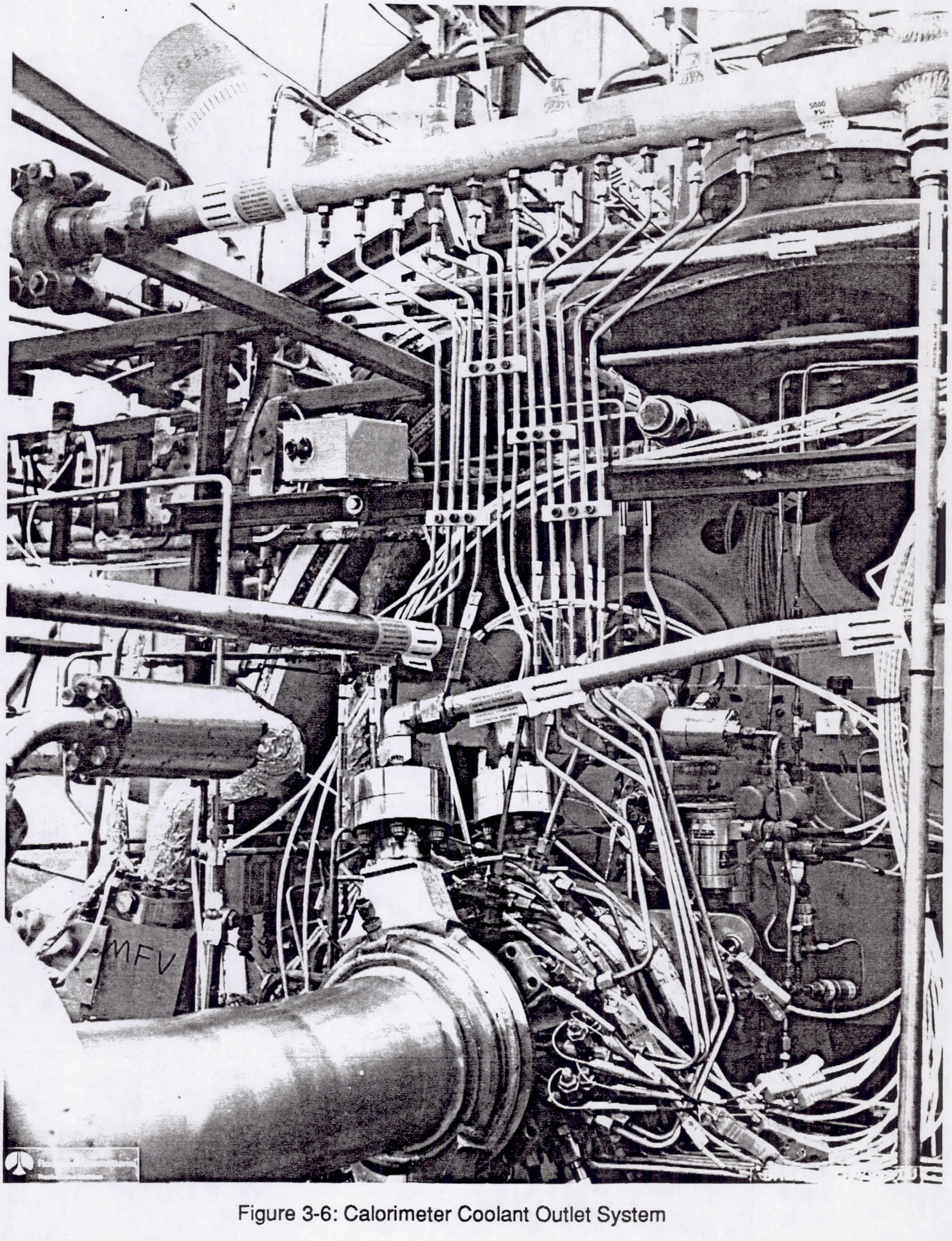

Figure 3-6: Calorimeter Coolant Outlet System

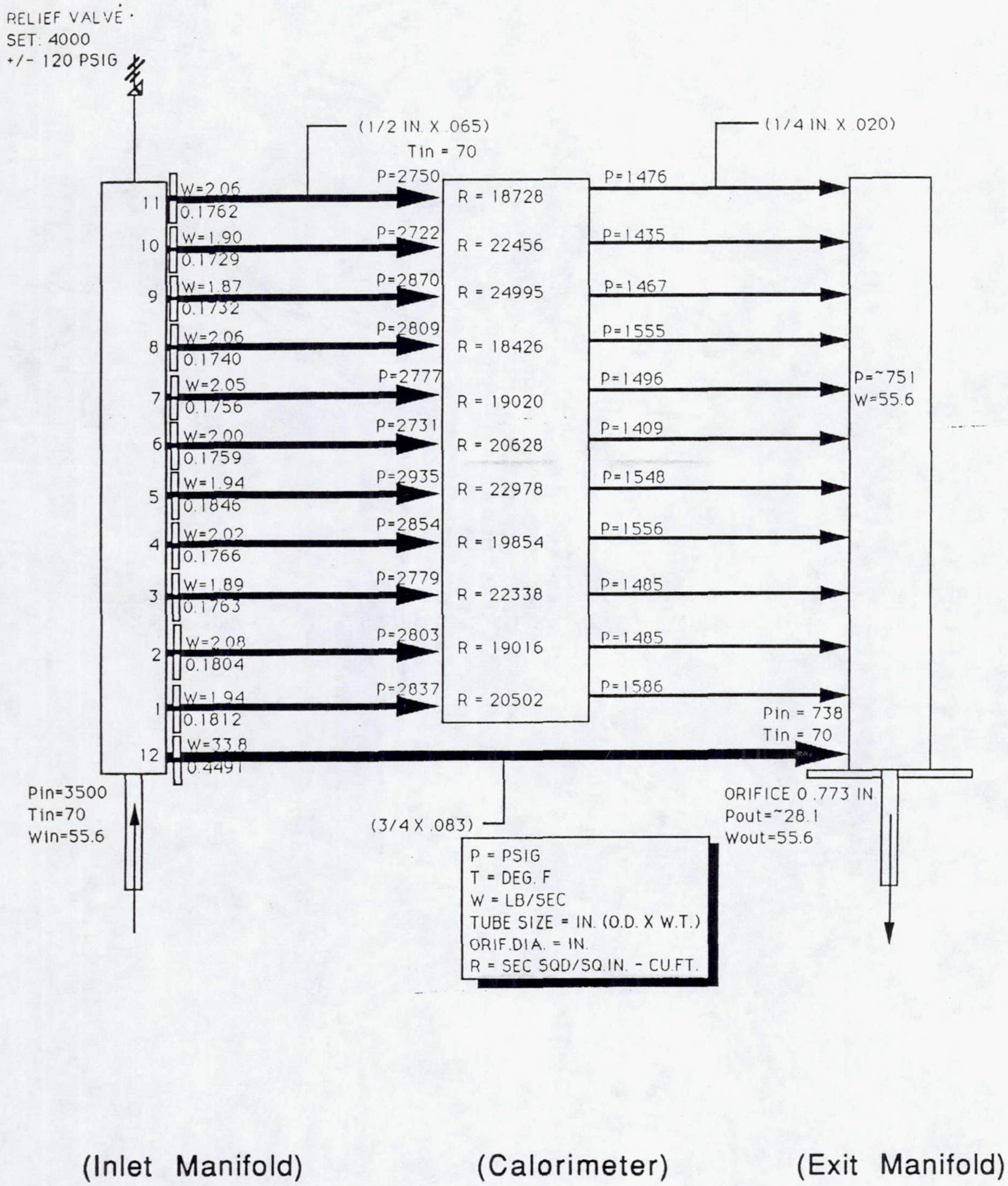

Figure 3-7: Calorimeter Coolant System Balance

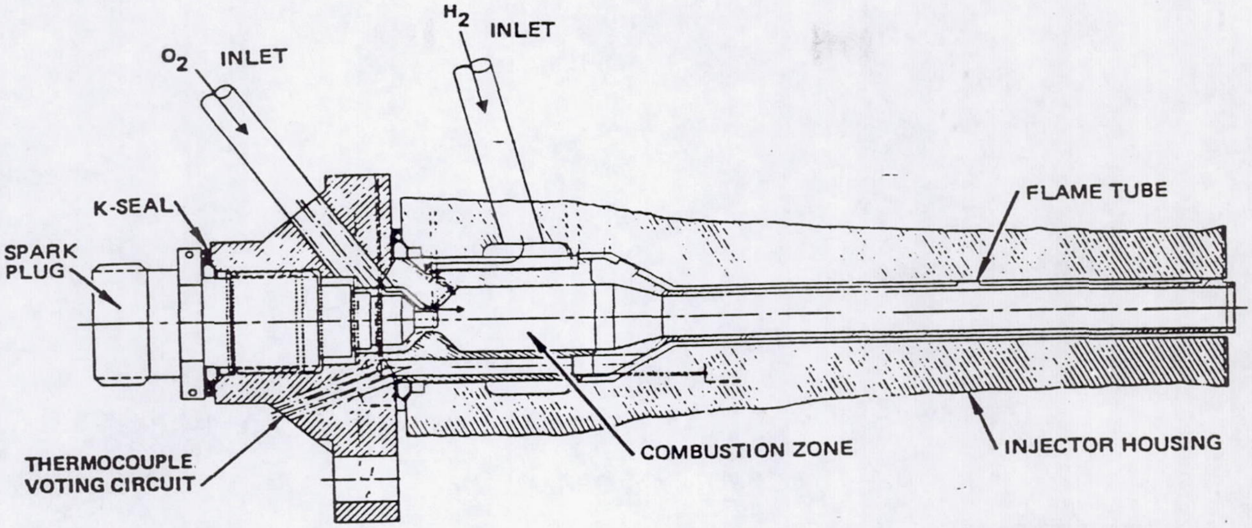

Figure 3-8a: I.C.E. Plasma Torch Igniter

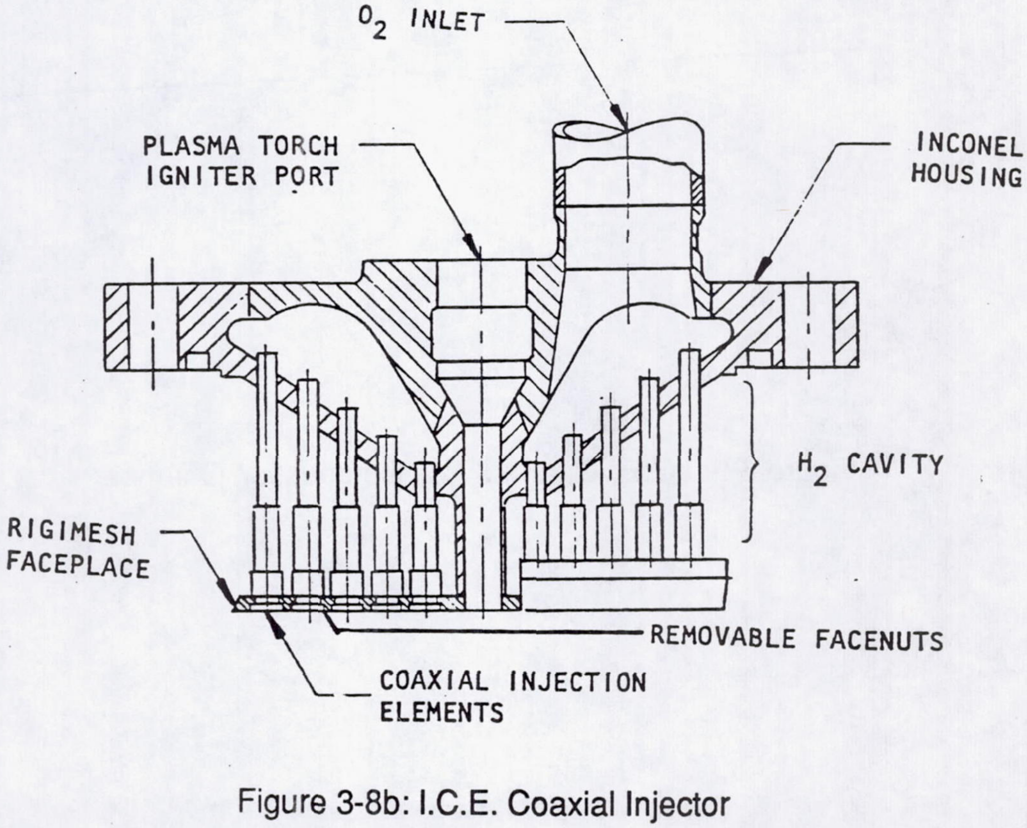

Figure 3-8b: I.C.E. Coaxial Injector

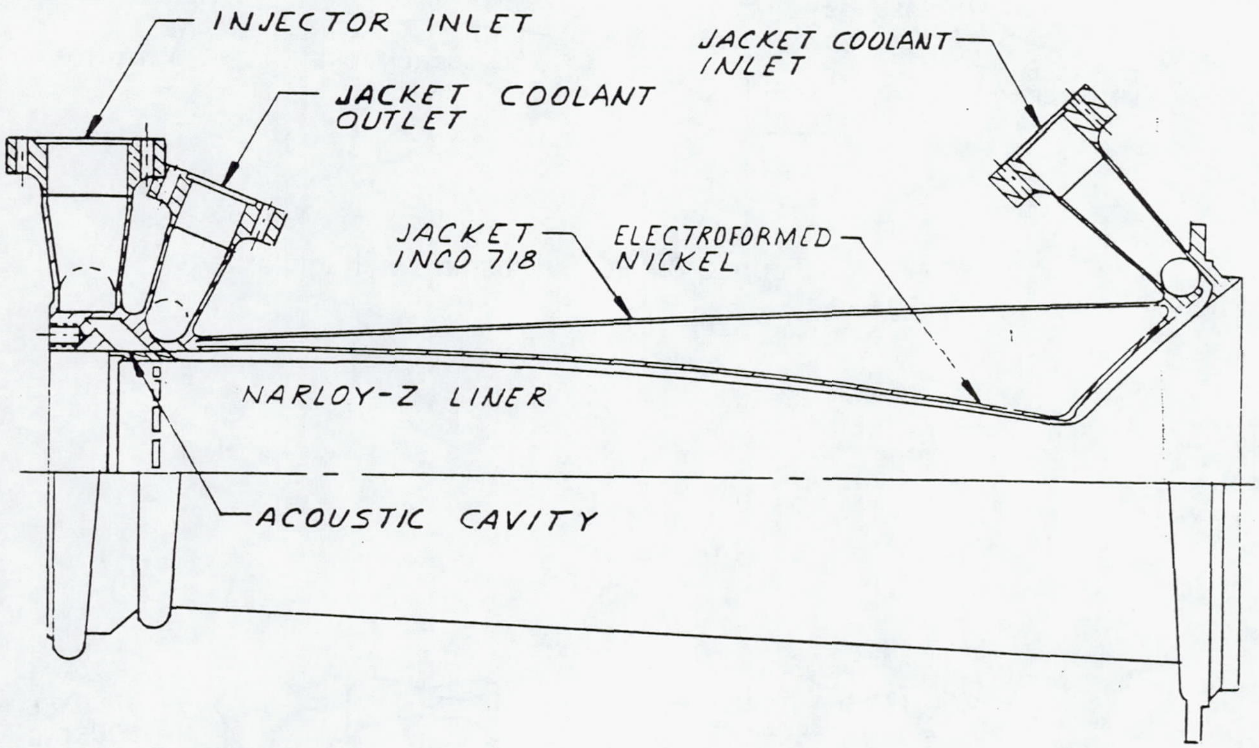

Figure 3-9: I.C.E. Tapered Wall Combustion Chamber

The acoustic cavities are normally cooled by the coolant passing along the channels on the backside of the liner. As a result of the thrust chamber modification, the cavities were placed in a position which had a much higher heat load than near the injector face where they are normally located. As a result, after the 1060 psia smooth wall test (017-042, the last of the steady state tests for this task effort), three of the 18 acoustic cavities had minor erosion. Should further testing occur, a series of 0.060 in. coolant holes would need to be drilled into the cavities from the inside of the original fuel manifold. These coolant holes would cool the cavity walls sufficiently to stop further deterioration of the acoustic cavities and allow for continued test.

3.1.6 35:1 Sea-level Nozzle - The nozzle was a single pass, channel wall, copper base alloy (Narloy-Z) configuration structurally reinforced to withstand sea-level operation and under-expanded transient flow. The nozzle extends the area ratio to 35:1 which allows the hot-gas flow to fully develop at a Pc = 770 psia. The nozzle was hydrogen cooled by a single down-pass circuit fed from the discharge of the combustor coolant jacket.

3.1.7 Test Facility Main Fuel and Oxidizer Valves - The main propellant valves were modified Advanced Space Engine pneumatically controlled valves. These ball valves were converted to hydraulic modulating control valves. Both valves were used in previous I.C.E. engine tests. For this hot-fire test series both were modulated in an open loop control mode to vary mixture ratio.

3.1.8 Fuel Feed Manifold - A new fuel manifold was required to feed the modified thrust chamber injector due to the fact that the original fuel manifold was welded to the combustion chamber. The new fuel manifold was identical to the original with the exception of bolt holes on the bottom which allow attachment to the calorimeter combustor.

3.1.9 Rigimesh Screen - In order to protect the original fuel manifold from hot-fire affects, a protective screen made of stainless steel Rigimesh was employed, figures 3-10 and 3-11. The Rigimesh allowed GH_2 coolant to permeate the screen and keep the original fuel manifold cooled during hot-fire. This Rigimesh was machine rolled to create the cylindrical shape. An electron beam weld was made to hold the two halves together as one piece. The Rigimesh is held structurally together by two stainless steel rings which are EB welded to the Rigimesh. The Rigimesh screen subsequently suffered a structural failure due to buckling, but did not allow hot-gas to damage the original fuel manifold.

3.1.10 Zirconium Oxide Coated, Transpiration Cooled Narloy-Z Cylinder - The Rigimesh screen replacement consisted of a Narloy-Z cylinder with forward and aft end coolant channels on the outer diameter, figures 3-12 and 3-13. These channels conducted hydrogen into coolant holes under flanges at the forward and aft end of the cylinder. The inner diameter (hot-gas side) was coated with a uniform 0.010 in. of Zirconium oxide to reduce thermal loading to the parent material. The cylinder has 2700, 0.010 in. diameter coolant holes, as seen in figure 3-13. These allow 0.9 lbs/sec GH_2 coolant to permeate the wall. Radial direction thermal growth of the Narloy-Z cylinder, considered a major contributor to the Rigimesh screen buckling failure has

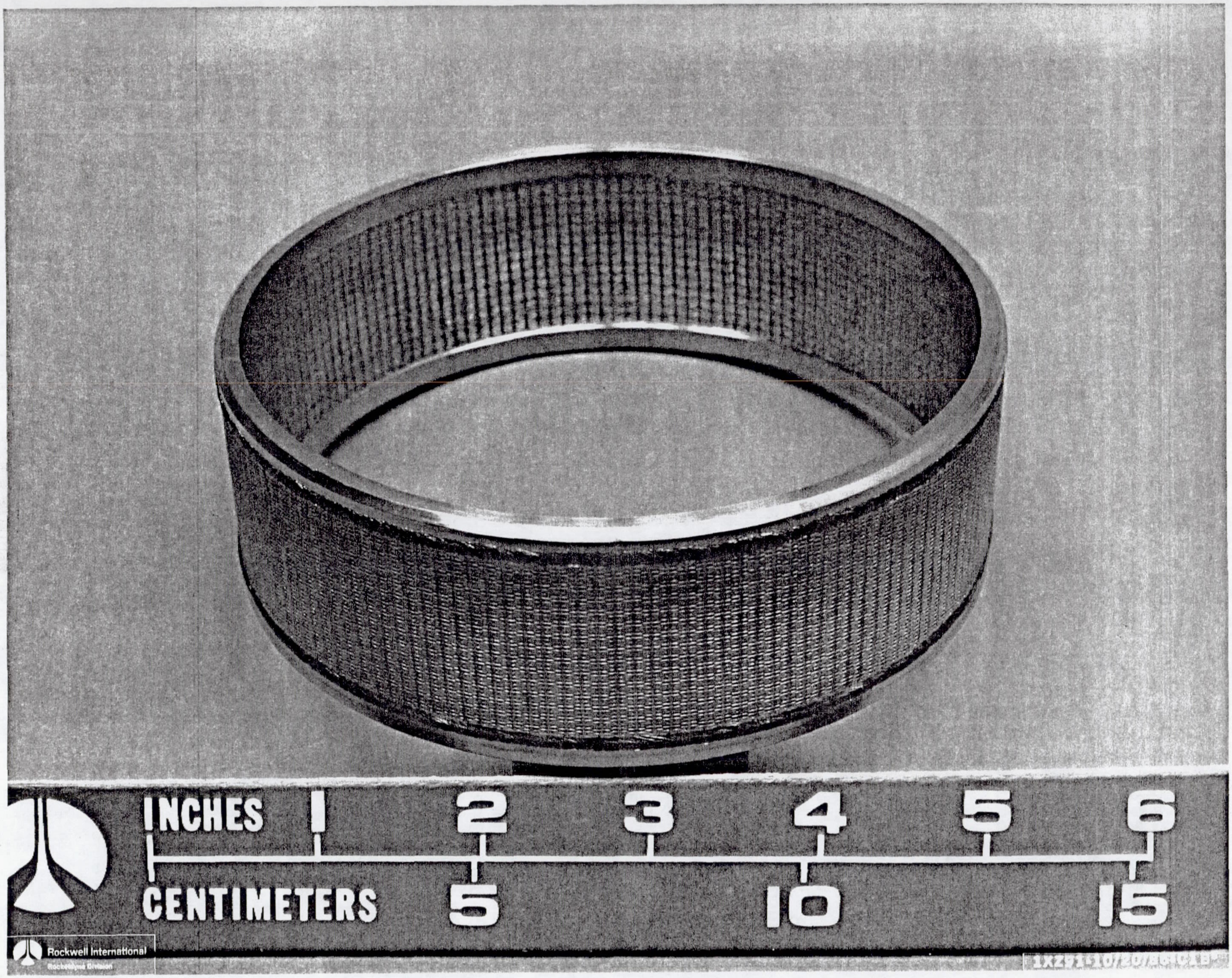

Figure 3-10: Stainless Steel Rigimesh Cylinder

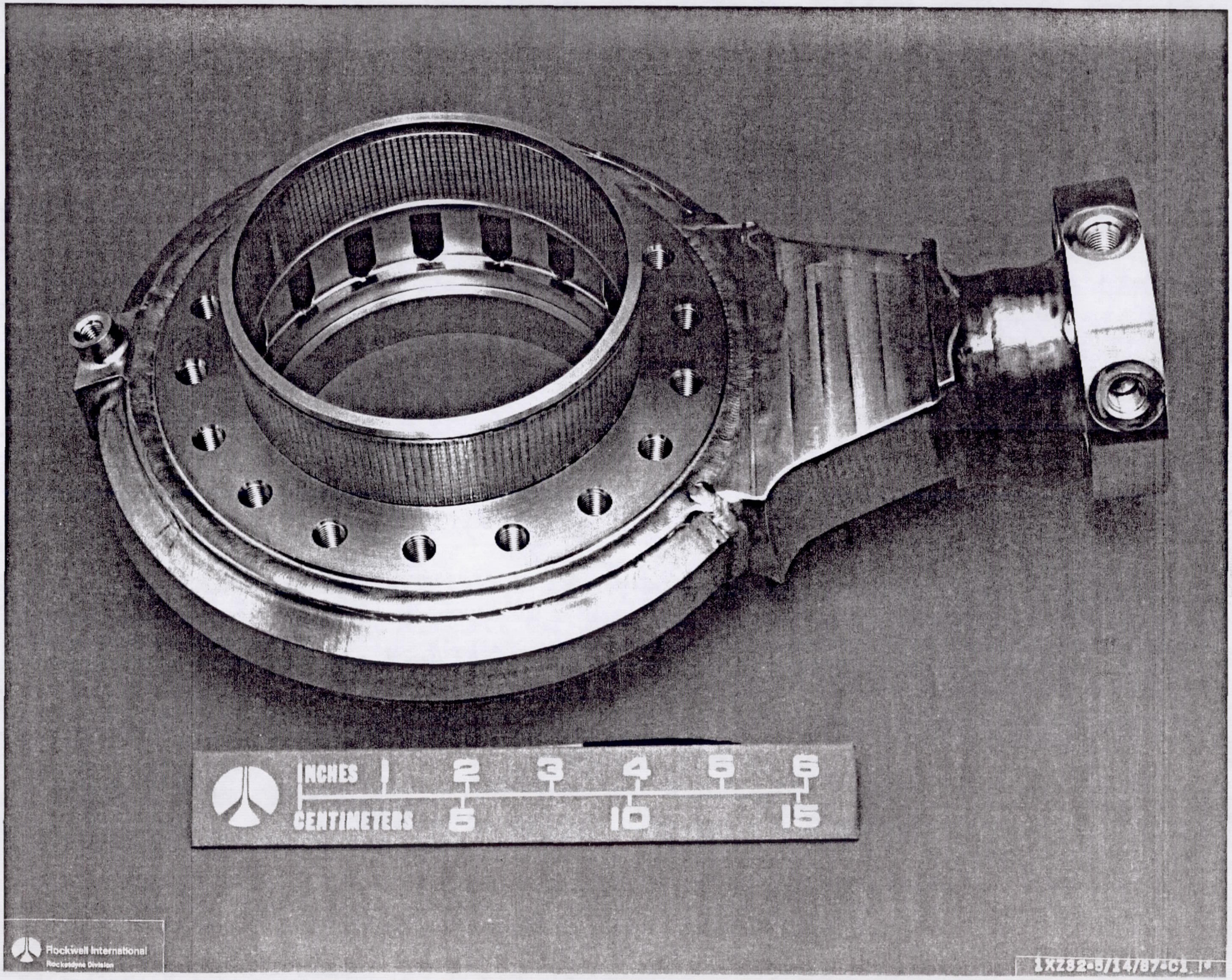

Figure 3-11: Fuel Manifold with Rigimesh Cylinder Emplaced

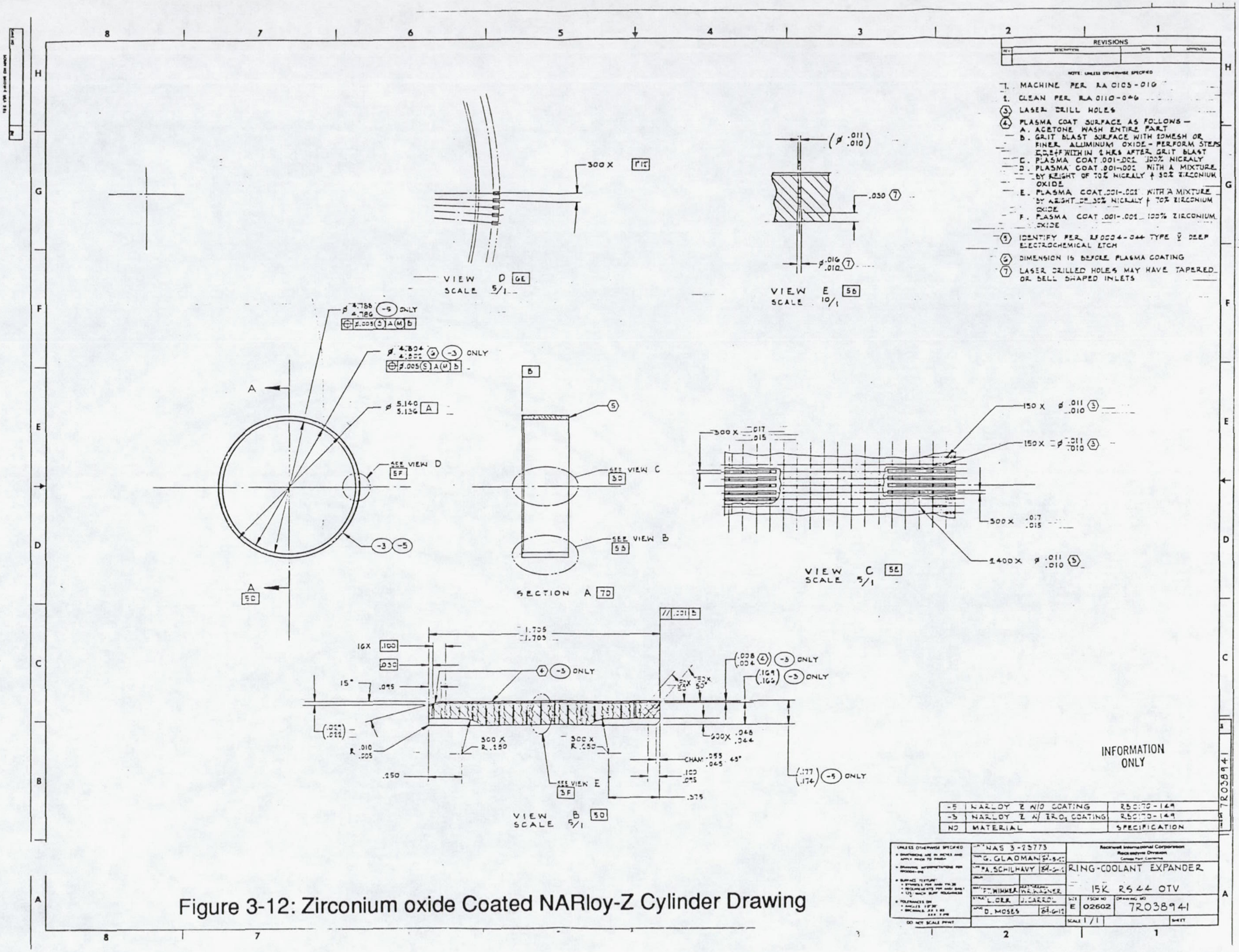

Figure 3-12: Zirconium oxide Coated NARloy-Z Cylinder Drawing

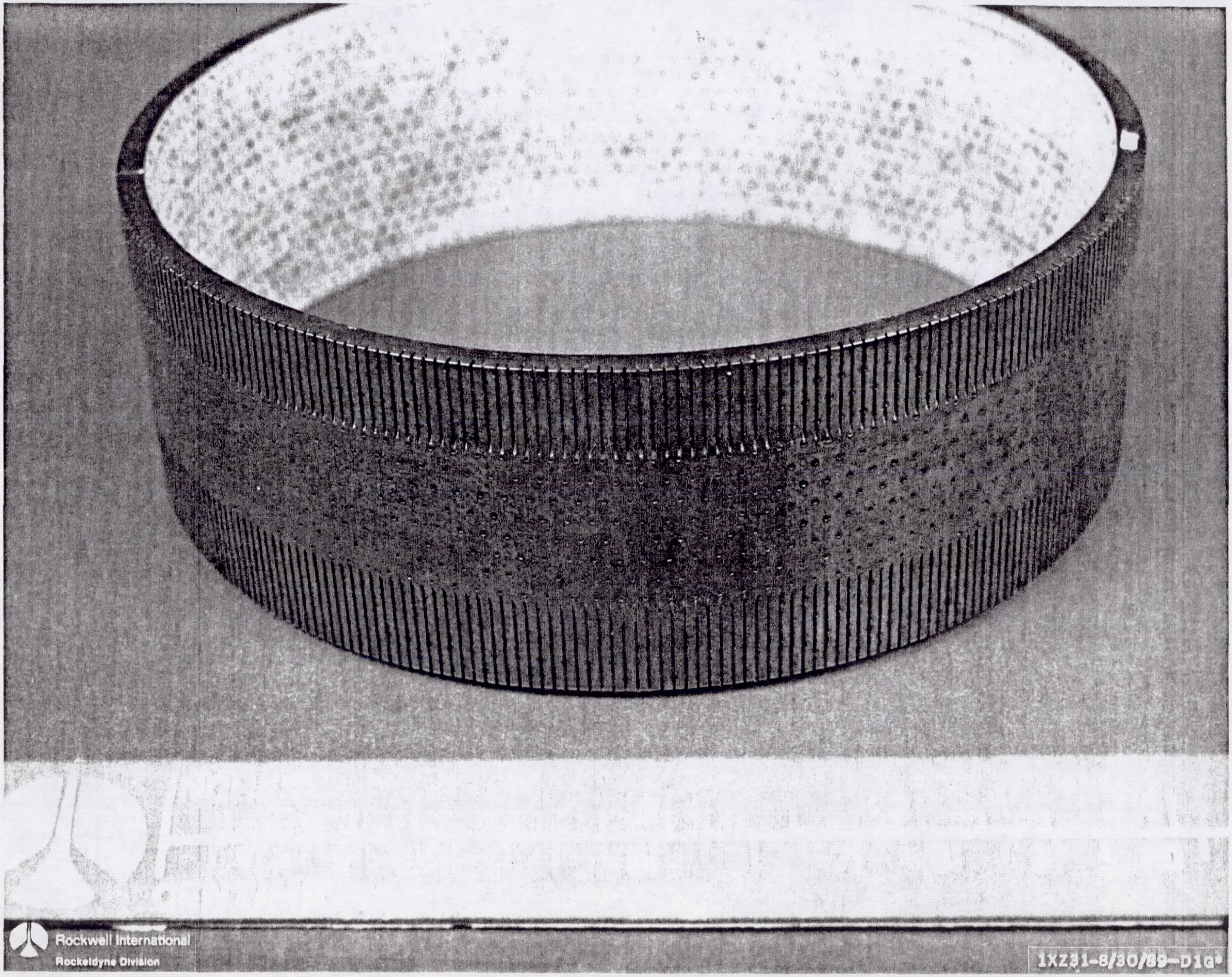

Figure 3-13: Zirconium oxide Coated NARloy-Z Cylinder Coolant Holes

been accommodated in the design by decreasing the outer diameter of the cylinder. A leading edge chamfer allows a smooth transition for the hot-gas flow assuming maximum radial displacement of the part.

3.1.11 I.C.E. Thrust Chamber Injector Feedline - The enhanced heat transfer combustor was tested with the I.C.E. in a thrust chamber only configuration instead of a complete engine, figure 3-1. This necessitated a new duct to be fabricated which would connect the nozzle outlet manifold with the new fuel manifold. These connections were previously made using various ducts and the high pressure oxidizer and fuel turbopumps. Orificing was provided to simulate the pressure loss created by the turbopumps.

3.1.12 APTF NAN-stand Preparation - The thrust chamber only testing was conducted on the NAN test stand position of the Advanced Propulsion Test Facility (APTF) at the Rocketdyne Santa Susana Field Laboratory (SSFL). The thrust chamber was mounted horizontally. The facility high pressure run tank and pressurizing tank systems were used. These provided test durations in excess of 15 seconds at mainstage in a high pressure blowdown mode.

3.1.13 Data Acquisition and Instrumentation - Details of the data acquisition and instrumentation systems are presented below:

3.1.13.1 Data Acquisition - The 128-channel Data General Digital Data Acquisition System (DDAS) was used to provide simultaneous data acquisition and test control functions. The system consists of three interfacing subsystems: 1) Data General S/140 CPU, 2) a basic input/output subsystem, and 3) Neff 620/500 amplifier/channel multiplexer. The DDAS operated at a sampling rate of 50,000 measurements per second. The test control program was loaded and executed by the Data General S/140 CPU. All data acquisition, control, and redline functions were controlled by the CPU. The Neff multiplexer continuously scans the 128 analog data channels and performs an analog-to-digital signal conversion; it then serially inputs the signal into the CPU. The CPU then performs comparison checks for signals exceeding any redline limits as specified in the test control program.

3.1.13.2 Temperature - Temp. Bulb sensors were used for critical temperature measurements (temperature range from cryogenic to 212 deg. F), and thermocouples were used for all other temperature measurements. A total of twenty-six temperature measurements were taken.

3.1.13.3 Pressure - All low frequency pressure measurements were made using strain-gage type transducers manufactured to Rocketdyne specifications. Approximately 38 pressure measurements were made. In addition, a high frequency piezoelectric pressure sensor was located on the LOX dome to monitor any flow or chamber instabilities.

3.1.13.4 Flow - Liquid flow measurements were made using sub-critical venturi flowmeters. Gas flows were measured using critical and subcritical flow venturis. Pressure, delta P and temperature measurements from these venturis were taken to obtain actual flowrates. Calorimeter water flowrates were obtained using calibrated orifices with known discharge coefficients.

3.1.13.5 Vibration - The thrust chamber had four accelerometers placed on the combustion chamber to monitor radial and axial loading.

4.0 THRUST CHAMBER TEST HARDWARE PERFORMANCE

4.1 HOT-FIRE TEST SERIES MATRIX AND SUMMARY OF TEST SERIES

The hot-fire test program was defined in a test plan approved by Rocketdyne OTV program and APTF management with NASA Lewis Research Center concurrence. The specific test plan was submitted at a Test Operational Readiness Review which insured that all NASA LeRC and Rocketdyne objectives, requirements and procedures were properly addressed. Test Requests were submitted for each individual test to define particular test objectives and requirements. The hot-fire test series was divided into two categories: start transient and the steady state tests. The start transient tests were designed to characterize the start sequence, hardware priming times and ignition.

The test series objectives were achieved by activating the propellant systems and building on each test. Successful water and LOX blowdowns were conducted on the calorimeter and thrust chamber systems. A successful ignition test characterized and confirmed the plasma-torch start sequence. This was followed by a successful fuel blowdown in which all systems (LH_2, GH_2, H_2O and ignition systems) were operated and characterized. A successful start transient test was achieved, characterizing the thrust chamber and facility performance.

The steady-state hot fire test matrix is presented in Table 4-1. A successful 15-second, **850** psia test with mixture ratio excursions was completed in test 017-016. The reduced data indicated that heat transfer to the calorimeter system was an average of 21% higher than predicted. Although heat loads were higher than predicted, testing at higher chamber pressures did not require modification of the water coolant system. Valve modulation and system performance were close to analytical model predictions. The mixture ratio excursions were varied, covering a range from 4 to 5.6 (O/F). NASA LeRC directed Rocketdyne to increase chamber pressure in smaller steps so as not to overload the calorimeter. The test plan was revised to conduct the next test at a chamber pressure of 1000 psia. Test 017-027 was a six-second, 1000 psia chamber pressure test.

Table 4-1. Steady State Hot Fire Test Matrix

Test Number	Calorimeter Configuration	Target Pc psia	Max. Obtained Pc psia	Test Duration Sec.
017-016	0.04 Rib	800	830	15
017-027	0.04 Rib	1000	1050	6
017-041	Smooth Wall	800	850	15
017-042	Smooth Wall	1000	1060	15

A close examination after test 017-027 showed that the Rigimesh screen, which protected the original fuel manifold from the hot-gas flow, had warped and buckled at the aft end. A failure analysis indicated that the Rigimesh failure was due to inadequate cooling of the forward and aft end stainless steel structural rings. The

replacement ring was a cylinder of Narloy-Z with 2700 laser-drilled coolant holes. A zirconium oxide coating was also applied to the hot-gas wall surface to preclude a high thermal gradient from structurally weakening the Narloy-Z.

The testing of the 0.040 in. ribbed calorimeter was discontinued in order to obtain smooth wall data. The calorimeter was machined smooth and re-installed into the test stand. After reassembly it was decided to use a complete series of blowdown, ignition and transient checkout tests, as some minor changes had been made to the system. Testing resumed to provide data for comparison with that obtained in the ribbed configuration. Prior to calorimeter data testing, checkout tests were completed to confirm that the replacement exciter system functioned properly and to characterize the performance of the Narloy-Z protective system (017-029). It was determined from test 017-029, that the delta P across the Narloy-Z was smaller than expected due to the mechanically floating nature of the cylinder. Therefore, it was decided to increase the GH_2 mass flowrate from 0.6 lbs/sec to 0.9 lbs/sec. This would provide sufficient coolant to the coolant holes and increase the delta P across the Narloy-Z. During the nominal start transient it was estimated that this delta P would approach 500 psid. The structural delta P maximum for the Narloy-Z at room temperature was 530 psid. Therefore the start transient was modified to minimize this effect. The GH_2 coolant valve was opened at the same time as the main fuel valve, with the main fuel valve initially set at a position which would increase the chamber pressure from less than 100 psia to over 200 psia. This action effectively managed the delta P across the Narloy-Z and kept it well below 300 psid. The cut-off transient was acceptable as the GH_2 coolant back pressure lagged slightly behind the decaying chamber pressure.

The smooth wall calorimeter 850 psia chamber pressure test, number 017-041, included a mixture ratio excursion. The mixture ratio excursion was not over as wide a band as anticipated. The 1060 psia chamber pressure test number 017-042 was then conducted. The mixture ratio excursions achieved values of 5.6,6.5, 7.0 and 5.0 during the 1060 psia Pc test.

4.2 I.C.E. THRUST CHAMBER TRANSIENT SIMULATION MODELING

The Integrated Component Evaluator thrust chamber performance was modeled prior to the initial hot-fire test to predict thrust chamber characteristics during hot-fire. An existing feed system computer model of the pump-fed RS-44 engine was modified to simulate the test article in order to determine:

1. Main propellant valve positions, sequencing and system response for an initial hot fire test at a chamber pressure (Pc) of 800 psia and an injector mixture ratio (MR) of 5.0.

2. LH_2 and LOX system blowdown test responses. (Ref. Appendix I)

3. Main Propellant valve positions for MR excursions from 5.0 to 7.0 at constant chamber pressures of 800 psia and 1200 psia. The 1000 psia chamber pressure test was modeled generating only numerical data (no plots).(Ref. Appendix II)

Once steady-state valve positions were determined by the model, a fuel lead open loop start sequence was formulated. This fuel lead would be followed 0.2 seconds later by opening of the main oxidizer valve (MOV). A mainstage Pc of 800 psia was predicted about 1.25 seconds from start of main fuel valve (MFV) opening. At shutdown, the valves would be closed simultaneously with a fuel lag obtained by closing the MFV at 50%/sec and the MOV at 100%/sec.

The start sequence was subsequently modified to provide delta P relief to the Zirconium oxide coated Narloy-Z protective cylinder, Figures 4-1 and 4-2. The main fuel valve initial set point was modified to open wider and provide increased chamber pressure to minimize the large delta P across the Narloy-Z cylinder during start up. The valve opening at 100%/sec began to flow hydrogen at the 35% open position. The GH_2 coolant supply valve which provided coolant to the protective cylinder was a fast acting pneumatic valve, which opened 0.35 seconds after the MFV was commanded open. At the same time, the main oxidizer valve was commanded open. The MOV and MFV do not flow propellant until they are ~35% open. Therefore, redlines were armed at this time to insure that both GH_2 coolant and GH_2 main propellant were flowing and primed by the time the main oxidizer valve began to flow, 0.35 seconds later. Prior to the main oxidizer valve reaching the first set point the main fuel valve was commanded to its second set point. It was timed to arrive at that position at the exact time that the MOV reached its first set point position. At this point chamber pressure increased until steady state was achieved.

The hot fire test simulation proceeded through its mixture ratio variation program using step functions each time the valves were modulated to new positions. During cut-off, the MOV was closed at 100%/second and the MFV was closed at 50%/second. The GH_2 coolant valve was closed at the cutoff signal as the pressure decay of the GH_2 coolant in the original fuel manifold lagged the chamber pressure. The pneumatic GH_2 coolant valve closure rate was timed to be approximately the same as the MFV closure rate of 50%/second.

A LOX blowdown, test number 017-001, was conducted to characterize LOX side flow resistances and priming time. A fuel blowdown test, number 017-008, was conducted to characterize fuel and coolant system performance. This test consisted of operating the main fuel propellant, gaseous hydrogen fuel manifold coolant system, ignition system and the water combustor coolant system. A second fuel blowdown test, number 017-029, was conducted after the Rigimesh system had failed and was replaced by the transpiration cooled NARloy-Z ring. This was required to characterize the flow performance of the transpiration cooled ring and the modified start sequence which was formulated to keep the delta P across the protective ring to a minimum. The results of these tests were iterated into the performance model and used to more accurately predict thrust chamber response. The fuel and oxidizer blowdown model results are shown in Appendix I. The mainstage tests with the mixture ratio excursions at a constant Pc revealed that only a small range of valve position movement was required. For the 800 psia Pc operation the MFV position closed just over 5% and the

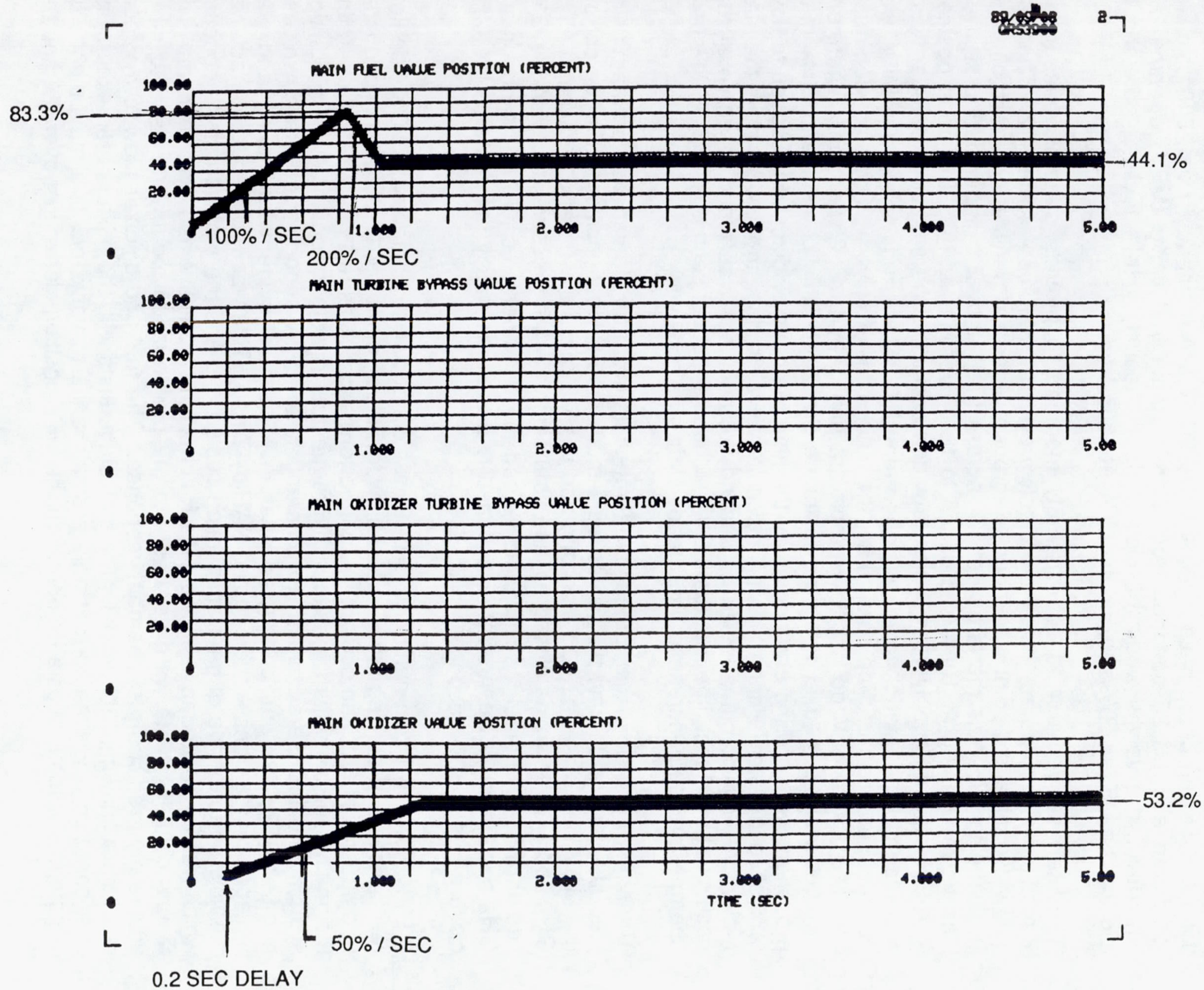

Figure 4-1: Transient Simulation Case I

CHANGED MFV SEQUENCE TO ELIMINATE "DIP"
IN CHAMBERPRESSURE CAUSED BY CASE I

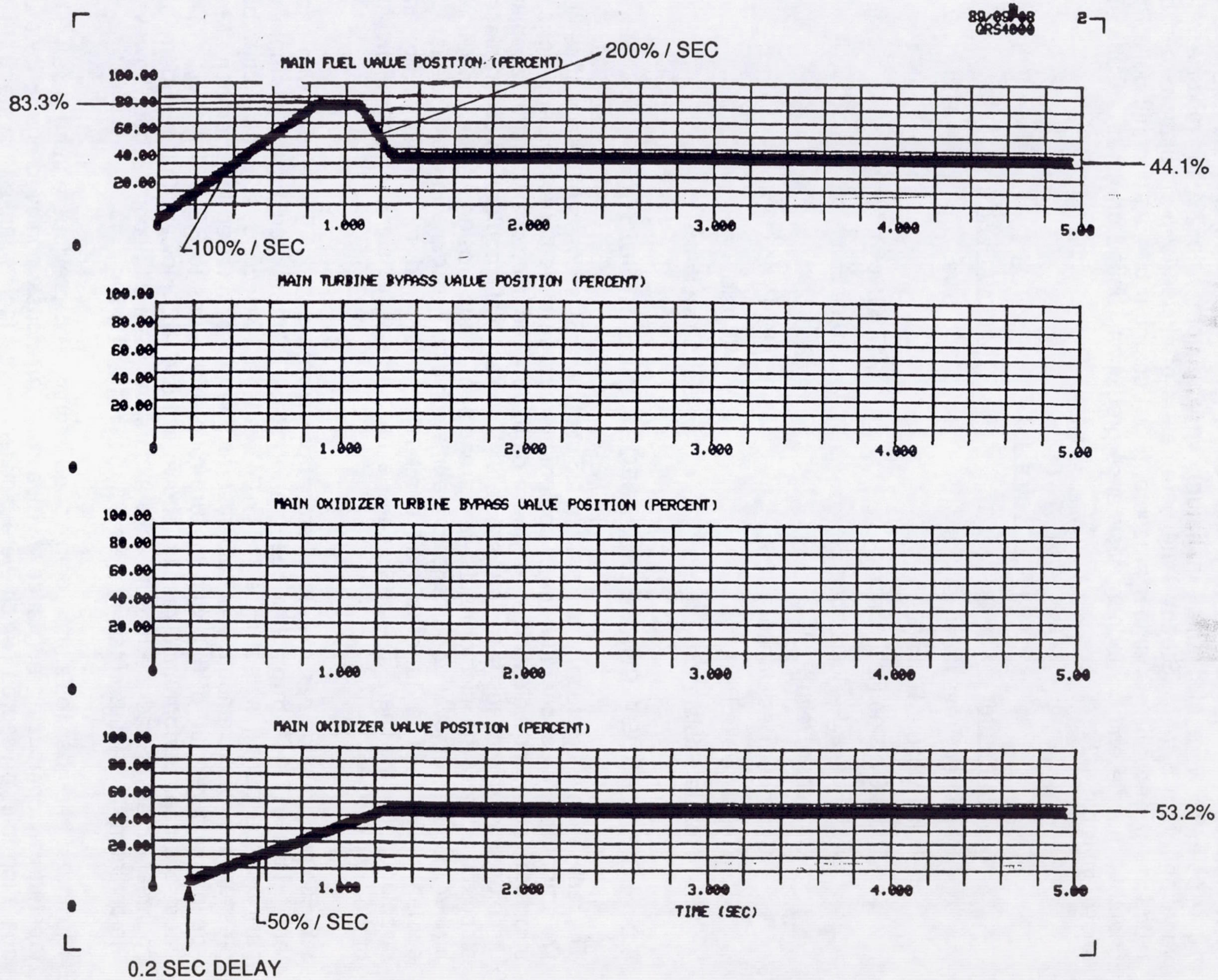

Figure 4-2: Transient Simulation Case II

MOV opened less than 2% to vary MR from 5 to 7. Corresponding adjustments at 1000 psia Pc were also small in nature, varying from 1 to 7% for mixture ratio variations from 5 to 7. Steady-state parameters of closed-loop simulations can be found in Appendix II. Chamber pressure, thrust chamber cooling channel delta P's, chamber, nozzle and component resistance predictions based on model results are shown in Table 4-2.

Table 4-2

Parameter	Predicted Value
Chamber Pressure	800 psia
Initial Mixture Ratio (O/F)	6.0
INJ. LOX side Resistance	47.6 $sec^2/ft^3\text{-}in^2$
INJ. Fuel side Resistance	8.0 $sec^2/ft^3\text{-}in^2$
Chamber Delta P	200 psid
Chamber Resistance	110.4 $sec^2/ft^3\text{-}in^2$
Nozzle Delta P	40 psid
Nozzle Resistance	3.8 $sec^2/ft^3\text{-}in^2$

4.3 I.C.E. THRUST CHAMBER PERFORMANCE RESULTS

The test series subjected the hardware to 25 starts and 51 seconds of steady state hot-fire time. The thrust chamber major component hardware did not exhibit any signs of structural fatigue or indication of hardware damage. The injector had minor faceplate discoloration and minor faceplate erosion. The faceplate coolant holes emplaced along the edge of the injector to alleviate areas of previous erosion were effective. No further material removal or damage to the injector face was done in those areas with coolant holes. The tapered wall combustor sustained minor blanching and discoloration of the liner. The 35:1 sea-level nozzle exhibited signs of minor blanching of the liner surface.

Specific performance parameters, chamber pressure, valve position, varied with each test. Test 017-041 thrust chamber performance is presented as an example of performance during a test. Test 017-041 was a 15-second, 850 psia chamber pressure test of the smooth wall calorimeter. The test plan called for operation at the nominal mixture ratio of 6.0, with mixture ratio excursions to 6.5, 7.0 and 5.0. The thrust chamber performance results, shown in table 4-2, indicate that test duration, chamber pressure and the mixture ratio excursions were all accomplished, however, the actual mixture ratios obtained were 5.6, 5.8, 6.1 and 5.7.

The thrust chamber resistance data varied slightly with previous engine data. The tapered wall combustor resistance was less than previously achieved due to lowered operating inlet pressures (which were dictated by the facility tankage system). The nozzle inlet pressure was also less than that run during the engine tests and therefore the resistance was slightly lower. Injector resistance data was a better indication of engine test resistance vs. thrust chamber resistance performance. The fuel side

Table 4-3 -- I.C.E. Performance Results

Parameter	Predicted	Actual	% Difference
017-041 -- Test Duration	15 sec.	15 sec.	--
Chamber Pressure	800 psia	850 psia	6.2
Initial Mixture Ratio (O/F)	6.0	5.6	6.7
Mixture Ratio Exclusions	6.5, 7.0, 5.0	5.8, 6.1, 5.7	10.7, 12.8, 14.0
Injector LOX Side Resistance	47.6 $sec^2/in^2\ ft^3$	42.2 $sec^2/in^2\ ft^3$	11.3
Injector Fuel Side Resistance	8.0 $sec^2/in^2\ ft^3$	9.8 $sec^2/in^2\ ft^3$	22.5
Chamber Resistance	110.45 $sec^2/in^2\ ft^3$	123.5 $sec^2/in^2\ ft^3$	11.8
Chamber Delta P	200 psid	209 psid	4.5
Nozzle Resistance	3.76 $sec^2/in^2\ ft^3$	3.98 $sec^2/in^2\ ft^3$	5.8
Nozzle Delta P	35 psid	30 psid	14.2

resistance was identical to that measured during engine tests. The LOX side resistance was slightly lower due to a slightly lower operating inlet pressure. This was from inaccuracies in predicting MOV resistance at the lower open area valve settings (caused by valve hysteresis). Table 4-3 presents thrust chamber resistance values.

The chamber pressure at ignition verification was 202 psia, which exceeded the minimum ignition chamber pressure (120 psia). The igniter core mixture ratio was 23.6, which was 2.43% off of the optimum core mixture ratio of 24.2. The coolant flow to the zirconium oxide coated Narloy-Z cylinder was 1.06 lbs/sec, which was 18% higher than the required 0.9 lbs/sec. This additional flowrate did not severely increase the delta P across the protective sleeve and aided in increased cooling of the sleeve.

5.0 CALORIMETER THERMAL PERFORMANCE

5.1 CALORIMETER THERMAL PERFORMANCE PREDICTIONS

The analysis performed to predict the rib and smooth wall heat flux was based on data obtained from the 40Klb SSME calorimeter data, scaled to the OTV engine thrust and chamber pressure levels. Results from the thermal analysis are presented to provide a direct comparison with the hot-fire test results. The analysis indicated that for the ribbed chamber at 850 psia chamber pressure, and a mixture ratio of 5.6, the average heat flux was 18.15 Btu/sq.in.-sec. For a chamber pressure of 1050 psia at a mixture ratio of 5.0, it would be 23.18 Btu/sq.in.-sec. **The I.C.E. calorimeter coolant system designed to operate at 1500 psia chamber pressure would operate well within the predicted heat load envelope.** The analysis indicated that for the smooth wall chamber at 850 psia chamber pressure, at a mixture ratio of 5.6, the average heat flux would be 11.88 Btu/sq.in.-sec. For 1050 psia chamber pressure it would be 13.68 Btu/sq.in.-sec, at a mixture ratio of 5.0. An overall enhancement of 42% was predicted (based on the 2-d lab results) for a 20-in. combustion chamber with a 16-in. barreled section as shown in Figure 5-1. In order to make comparisons between hot-fire ribbed data, smooth wall data and analytical data, comparisons were made at common mixture ratios obtained during all the hot-fire tests.

5.2 CALORIMETER THERMAL PERFORMANCE ACTUAL RESULTS

The heat transfer data from the 0.040 in. ribbed calorimeter combustor was obtained from two tests. Test 017-016, a 15-second 830 psi chamber pressure test and Test 017-027, a six-second, 1050 psia chamber pressure test. The heat load rate when plotted vs. combustor position (reference Figure 5-2) exhibited a pattern similar to previous calorimeter combustors. The heat load rate was higher at the calorimeter channel closest to the injector and then decreased in the second channel. This was followed by an increase in the third channel and a marked increase in the fourth channel. This pattern is characteristic of effects which occur close to the injector and has been noted in other calorimeter testing. The high heat load rate indicates that the hot-gas boundary layer has not attached to the wall of the combustor, and that possible re-circulation is occurring close to the injector faceplate outer edge which accounts for the high heat load rate close to the injector face. As the boundary layer attaches, around channel #4, the boundary layer thickness is very small and accounts for the increased heat load rate. As boundary layer thickness increased downstream of channel 4, slightly decreasing heat load rates were exhibited.

The heat transfer results from the ribbed combustor at 830 psia chamber pressure indicated that the mixture ratio excursions affected the heat flux as shown in Figure 5-3. The mixture ratio varied from 4.0 to 5.6 and increased the corresponding heat loading ~1.92 Btu/sec per 1.0 mixture ratio change over the specific range of 4.0 to 5.6. This increase was not observed during the smooth wall tests.

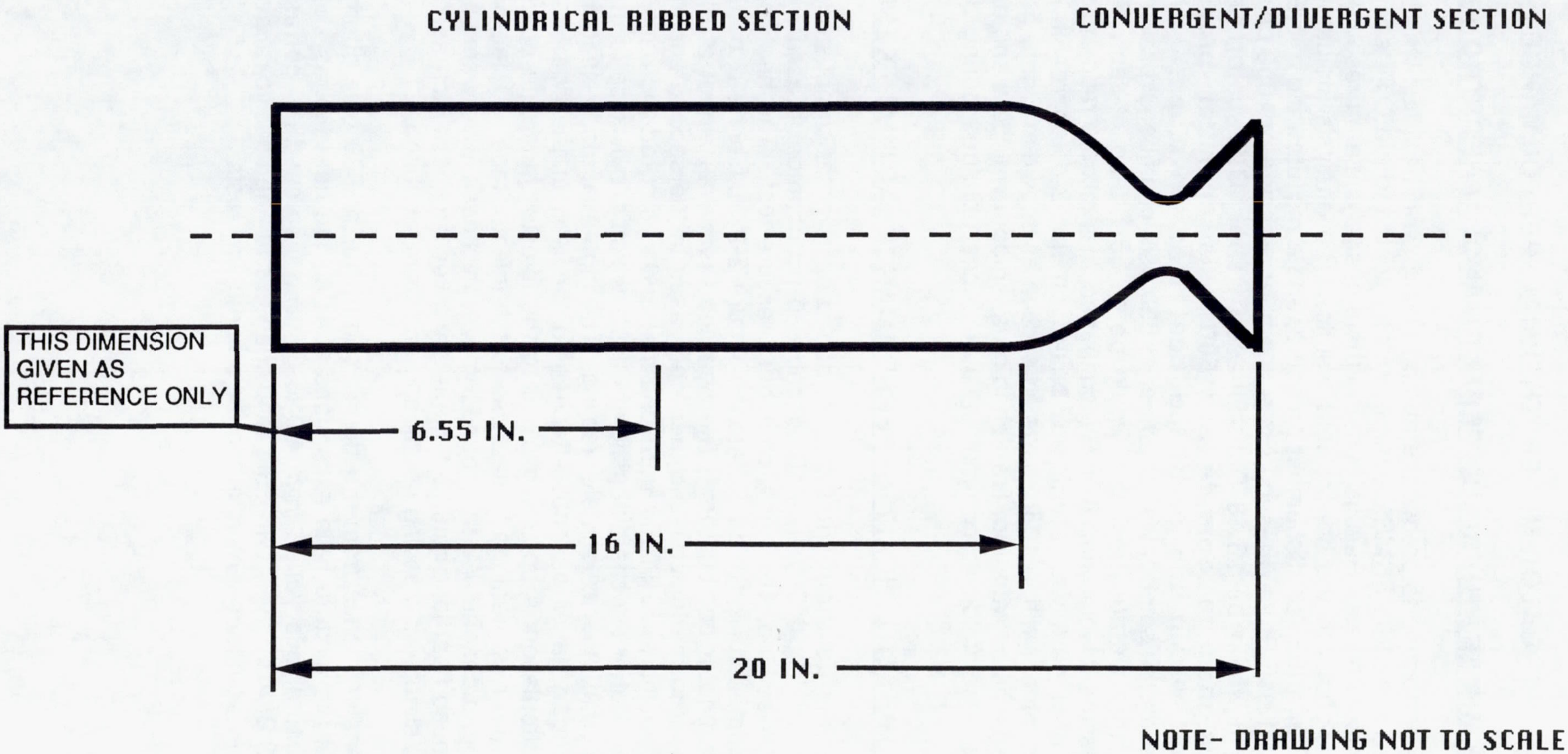

Figure 5-1: 15Klb Ribbed Combustor Geometry

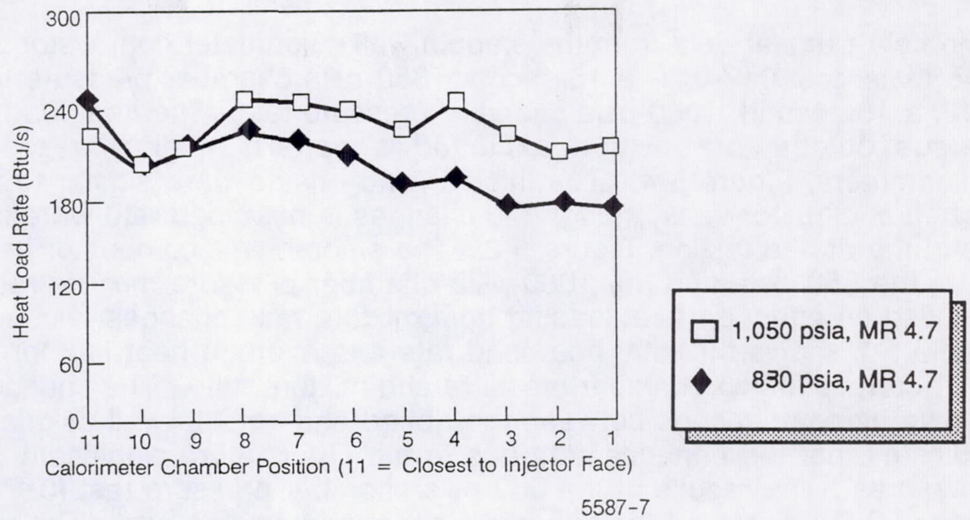

Figure 5-2: 0.040 in. Ribbed Calorimeter 830 & 1050 psia Pc Test Results (Tests 017-016 and 017-027)

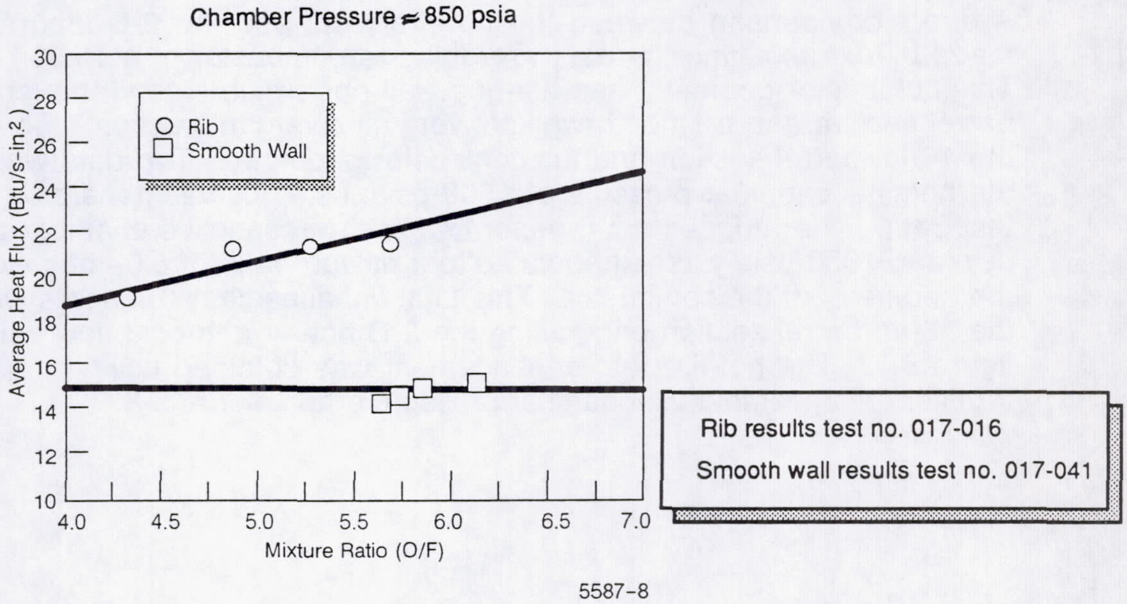

Figure 5-3: ~850 psia Pc Heat Flux vs. Mixture Ratio

The heat transfer data from the smooth wall calorimeter combustor was obtained from two tests: test 017-041, a 15-second, 850 psia chamber pressure test, and test 017-042, a 15-second, 1060 psia chamber pressure test. The heat load rate when plotted versus combustor position exhibited a pattern similar to previous combustor calorimeters, Figure 5-4. The injector end effects were similar to those seen in the ribbed combustor tests, though the changes in heat load rate were not as pronounced as in the ribbed testing, Figure 5-2. The smooth wall combustor heat transfer results from the 850 psia and the 1060 psia chamber pressure mixture ratio excursion tests showed no effect on heat loading from mixture ratio changes, as shown in Figure 5-5. Table 5-1 shows the total heat load rate and average heat flux for the calorimeter at their corresponding chamber pressure and mixture ratio. The change in heat load rate shown by comparisons between the ribbed and smooth wall calorimeter hot-fire tests indicates that the enhancement due to the ribs is more significant at higher chamber pressures. The results of the 850 psia chamber pressure test (017-016) at a mixture ratio of 5.6 indicate a 50% enhancement over a smooth wall. The 1050 psia chamber pressure test (017-027) indicated a 40% increase in heat transfer at a mixture ratio of 4.7. The decrease in enhancement between 850 psia and 1050 psia Pc tests can be attributed to the difference in mixture ratios. If the mixture ratios are normalized, then the enhancement is greater for the 1050 psia Pc test than for the 850 psia test, as shown in Figure 5-6. This indicates that the rib heat transfer enhancement is sensitive to changes in mixture ratio and chamber pressure.

5.3 PROJECTED FULL-SIZE RIBBED COMBUSTOR PERFORMANCE

A direct comparison between the hot-fire tests and the 2-D laboratory results was made by extrapolating the data to a full-size combustor of a 15,000 lb thrust engine. This combustor geometry has hot-gas wall ribs which extend the length of the 16 in. barrel section and a smooth wall convergent/divergent section. Figure 5-1 illustrates the 16 in. barrel section and full combustor geometry. The data was extrapolated to the nominal chamber pressure of 1500 psia, using curves generated from the hot-fire test data. The reduced data, generated at the respective chamber pressures of 850 psia and 1050 psia was extrapolated to a mixture ratio of 6.0, then extrapolated out to the geometry of the combustor. This total enhancement compares with 48% (60% for the 16 in. barrel section only) using the 2-D hot-air and cold flow velocimeter results, figure 5-7. The hot-fire test enhancement was obtained using curves from the heat transfer enhancement vs. chamber pressure graph, figure 5-8.

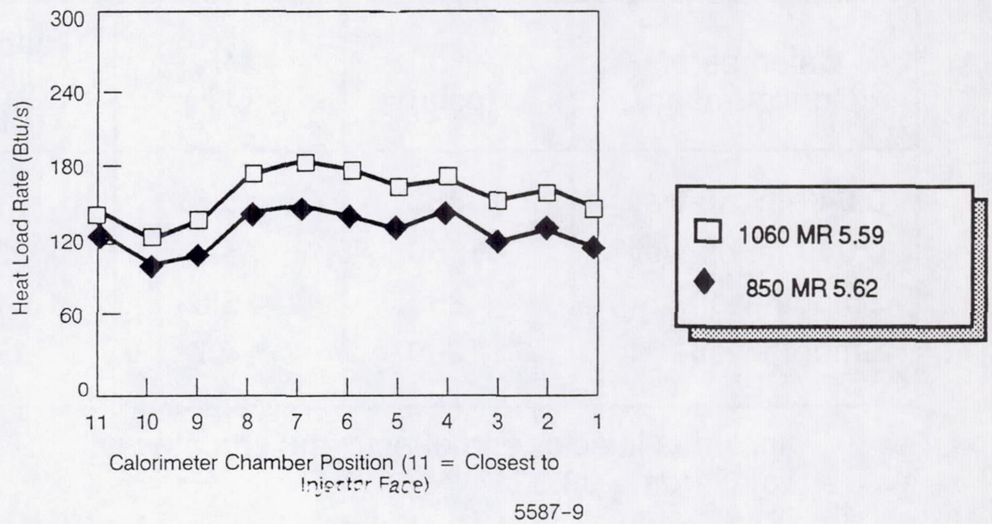

Figure 5-4: Smooth Wall Calorimeter 850 and 1060 psia Pc Test Results
Tests 017-041 and 017-042

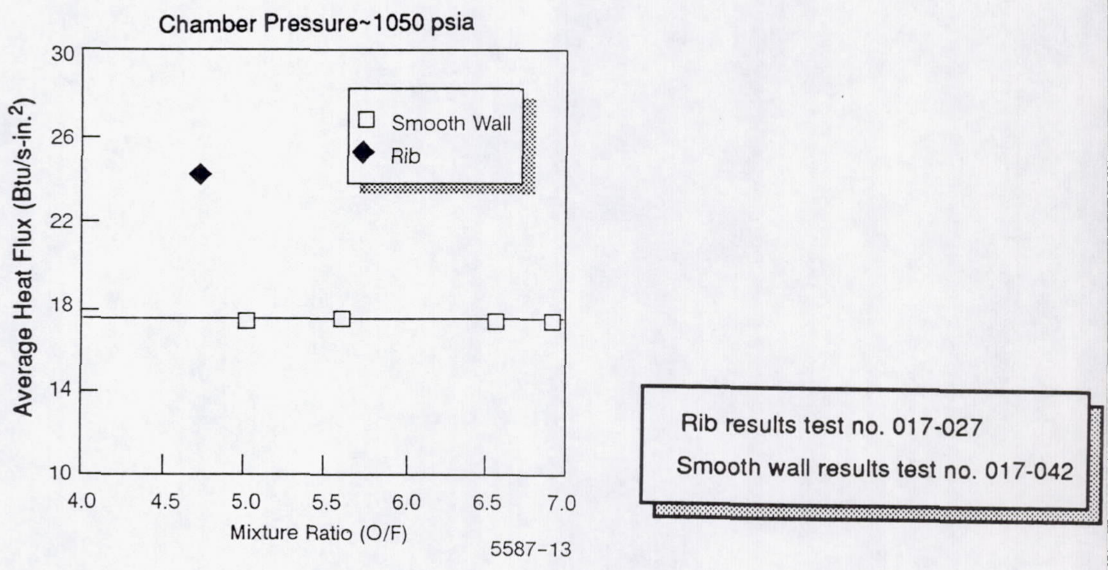

Figure 5-5: ~1050 psia Pc Heat Flux vs. Mixture Ratio

Table 5-1. Calorimeter Heat Transfer Performance Results

Calorimeter Configuration	Pc (psia)	MR (O/F)	Total Heat Load Rate (Btu/s)	Average Heat Flux (Btu/in^2 -s)*
0.040-in. rib wall	830	5.6	2122	21.5
0.040-in. rib wall	1050	4.7	2392	24.2
Smooth wall	850	5.6	1415	14.3
Smooth wall	1060	4.7	1722	17.4

*Includes injector end effects and smooth wall
Total area = 98.8 in^2

Table 5-1
TH/Bv 2/28/94

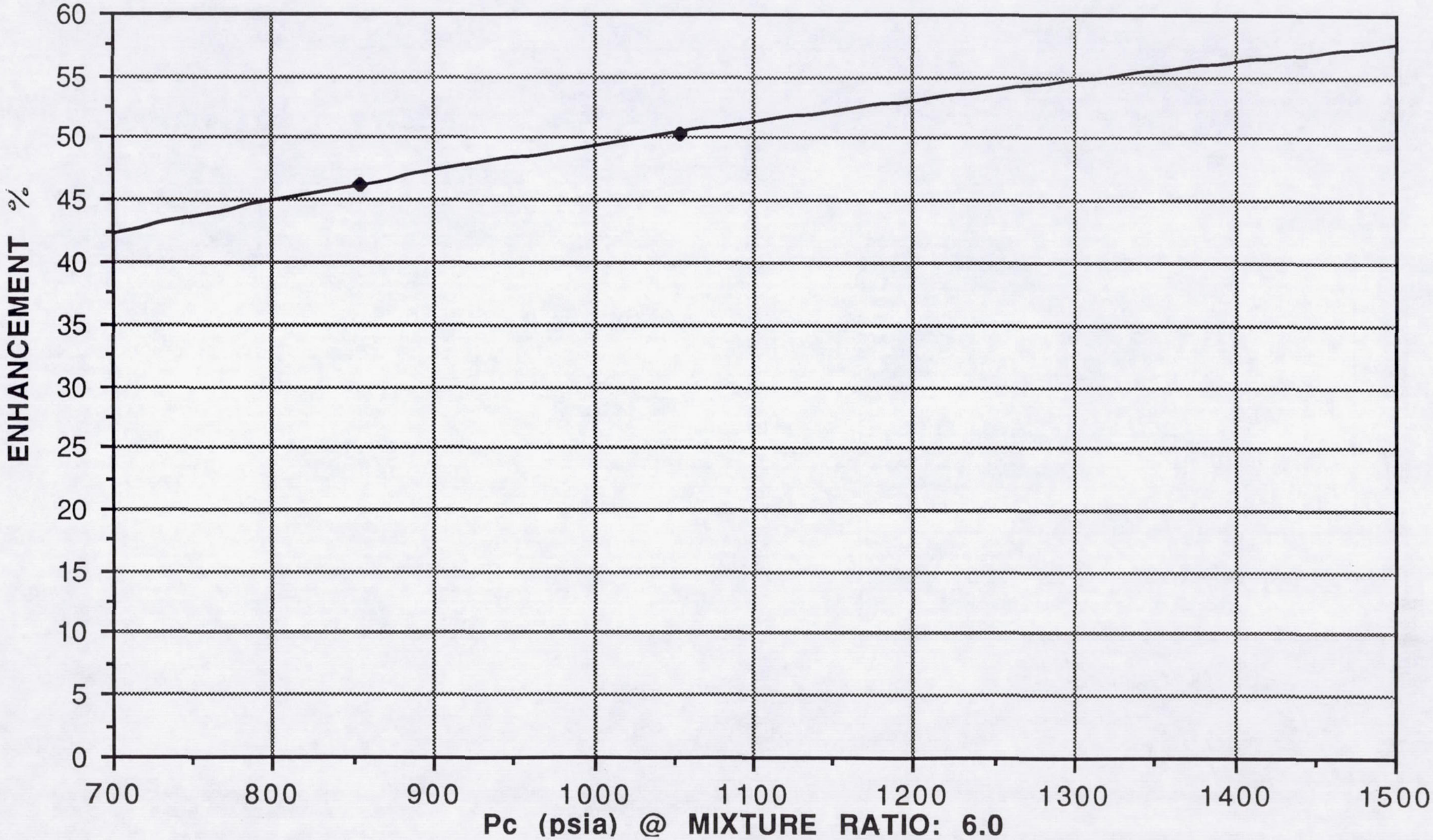

Figure 5-6: Enhancement vs. Pc for 6.55 in. Cylindrical Combustion Chamber

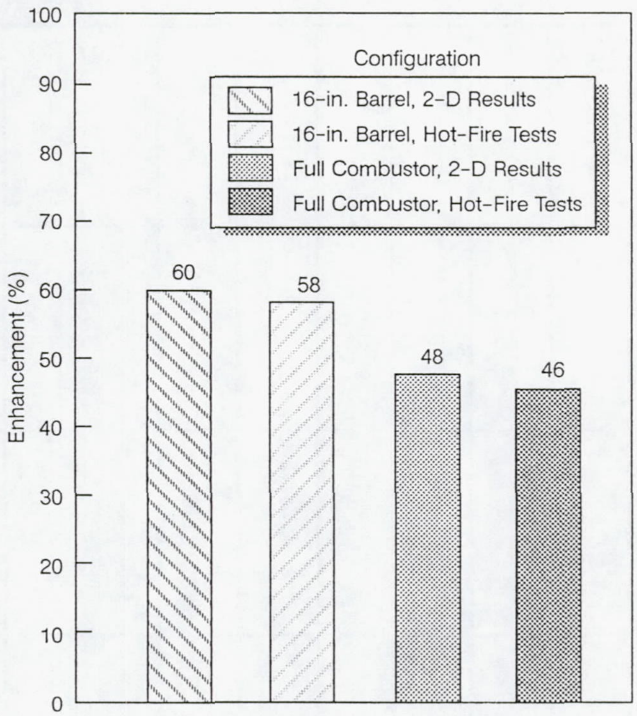

Figure 5-7: 15Klb Percent Enhancement Comparison

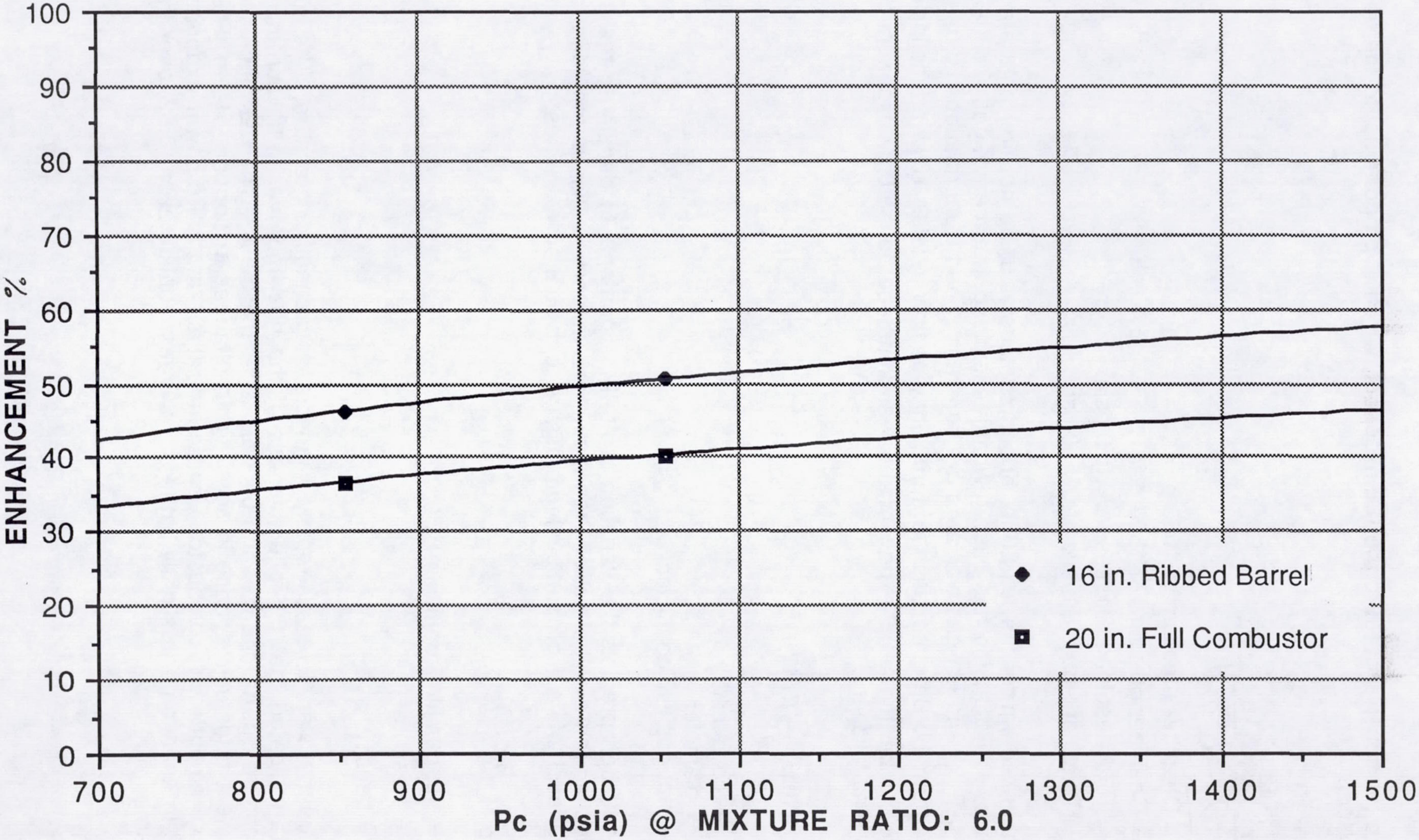

Figure 5-8: Enhancement vs. Pc for 16 in. Cylinder & 20 in. Full Combustor

If we use the relationship of Pc to the 0.8 exponent, which is proportional to the heat load, Q (Btu/sec).

$$\left(\frac{P_2}{P_1}\right)^{0.8} = \left(\frac{Q_2}{Q_1}\right)$$

where P_1= Chamber pressure of 1050 psia
P_2= Chamber pressure of 1500 psia
Q_1= Total heat load (Btu/sec.) at 1050 psia
Q_2= Total heat load (Btu/sec.) at 1500 psia

The total enhancement for the full 20 in. ribbed combustor using hot-fire test data is 40%. The above relationship has been rewritten assuming that the hot-gas wall delta T ($T_{adiabatic}-T_{wg}$) and hot-gas wall area are constant. The actual relationship used, which comes from the Bartz equation for turbulent pipe flow, relates h_g as a function of the Reynolds number to the 0.8 exponent and Prandtl number to the 0.33 exponent but can be written as follows:

$$hq = .023\ \frac{k}{D}\ Re^{.8}\ Pr^{.33}$$

where k = conductivity
D = diameter
hg = hot-gas film coefficient

The above equation predicts the variation of hg is proportional to density to the 0.8 power (neglecting the small effect of Prandtl number variation) which is the same as saying the variation of hg is proportional to pressure to the 0.8 power. Thus:

$$h_g \ \alpha \ Pc^{0.8} \ \alpha \ p^{\,0.8}$$

where h_g = hot-gas film coefficient
P_C = pressure
ρ = density

Therefore, heat transfer increases rapidly with increasing chamber pressure. The hot-fire test data indicated that the effectiveness of the ribs improves with increasing chamber pressure due to changes in boundary layer thickness. The data indicates that the rib heat transfer response is sensitive to changes in boundary layer when compared to a smooth wall combustor. It also indicates that the Pc power exponent, normally 0.8 in equation 1 is slightly higher for this test configuration, 0.82, over this range of chamber pressure.

6.0 CONCLUSION

A critical technology towards building an advanced expander cycle engine is achieving higher combustion chamber pressure, which gives higher overall engine performance. The increased heat energy extracted to drive the turbopumps maximizes the efficiency of the turbomachinery operation. In the past, the heat energy requirements of the turbopumps required longer combustion chambers. Size limitations created the need for a different method to increase heat extraction. This requirement was fulfilled by increasing the area exposed to the hot gas by using combustor ribs. The ribs increased the total area exposed to the hot gas by 80% and thus enhanced the heat energy level imparted to the coolant working fluid.

The resultant enhancement from the ribs for a 16-in. barrel section at 15Klb nominal performance levels is a 58% increase in heat transfer rate (when compared to a smooth wall combustor) which translates to a 46% increase in heat loading for a 15Klb combustor. The findings indicate that the ribs are as effective as previous analysis and 2-d subscale testing indicated. They also indicate that higher mixture ratios and chamber pressures can increase the effectiveness of 0.040-in. ribs. Continued hot-fire testing at higher chamber pressure (1,500 psia) and mixture ratios (>6.0) would more clearly define the relationship between Pc, mixture ratio, and enhancement in that regime.

APPENDIX

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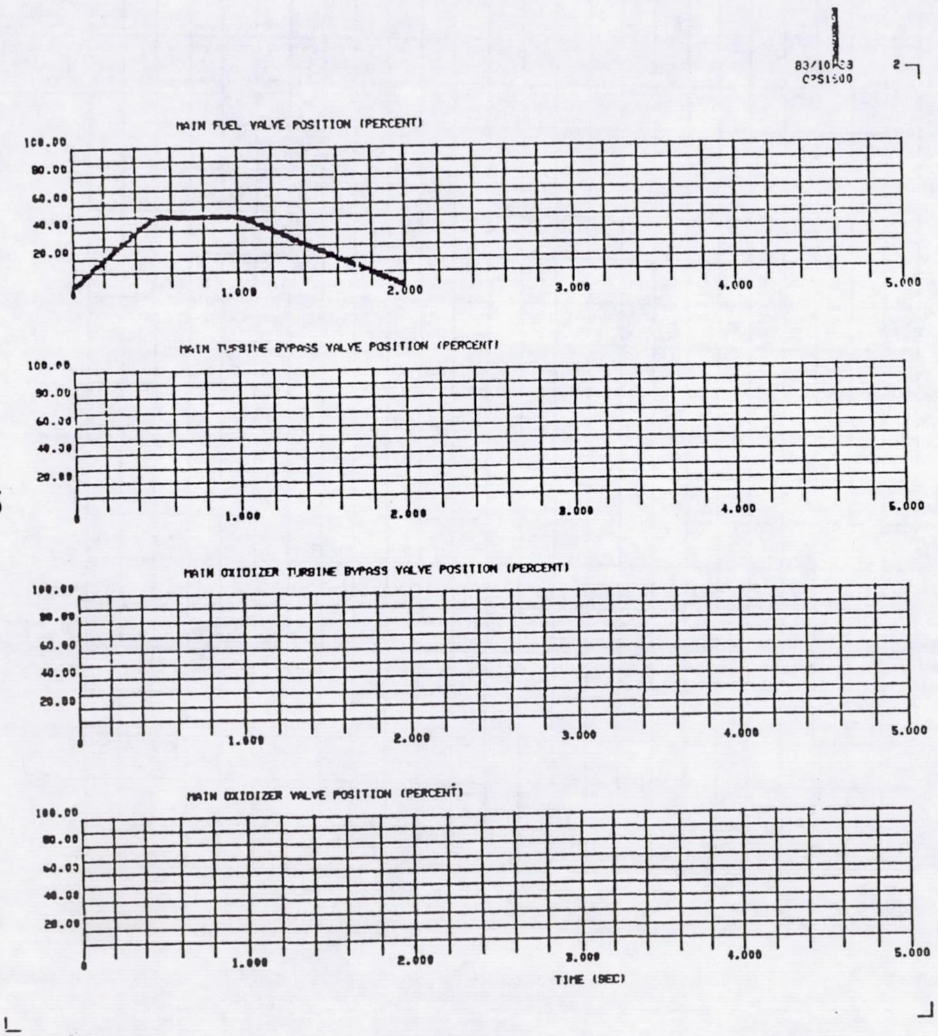
V. Drawings and Layouts of Calorimeter Insert and Related Hardware

APPENDIX I

I. Fuel System and Oxidizer System Blowdowns & Start Transient Simulation Runs

Fuel System Blowdown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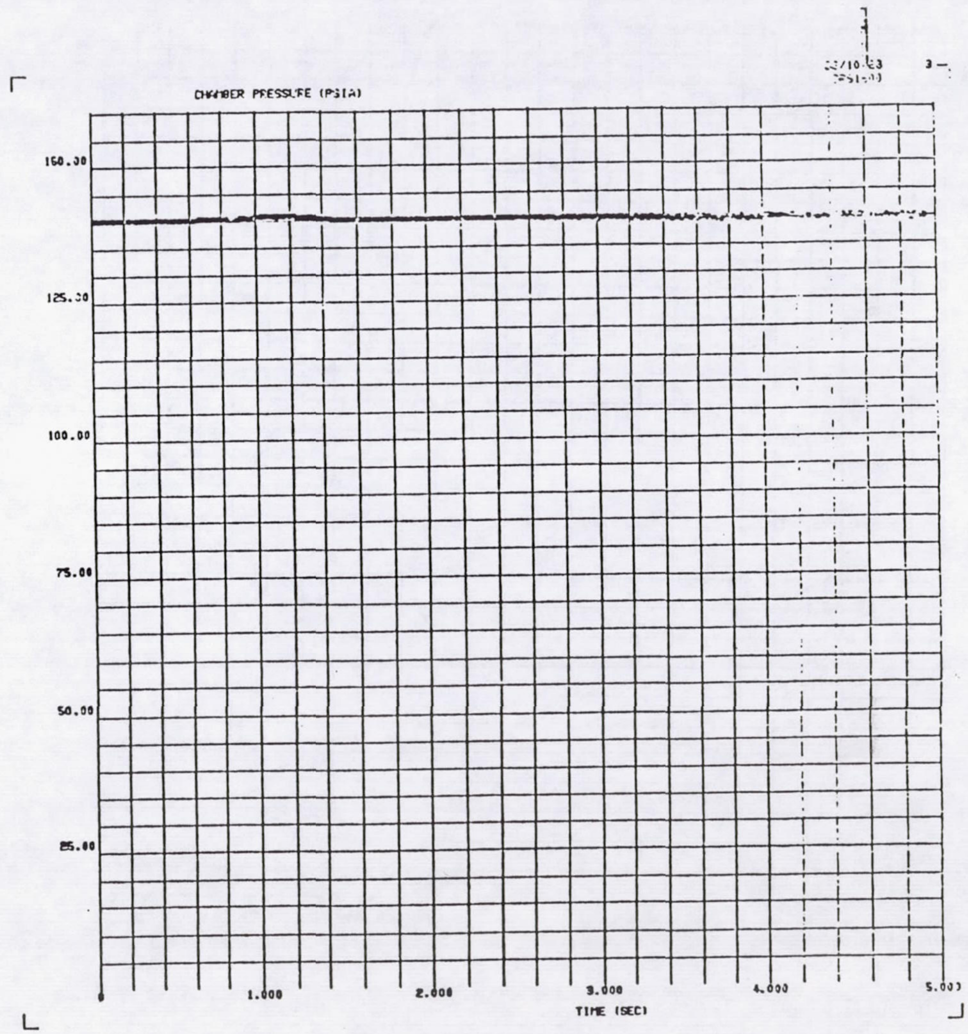
60.00
40.00
20.00
1.000
2.000
3.000
4.000
5.000
MAIN TURBINE BYPASS VALVE POSITION (PERCENT)
MAIN OXIDIZER TURBINE BYPASS VALVE POSITION (PERCENT)
MAIN OXIDIZER VALVE POSITION (PERCENT)
TIME (SEC)


3
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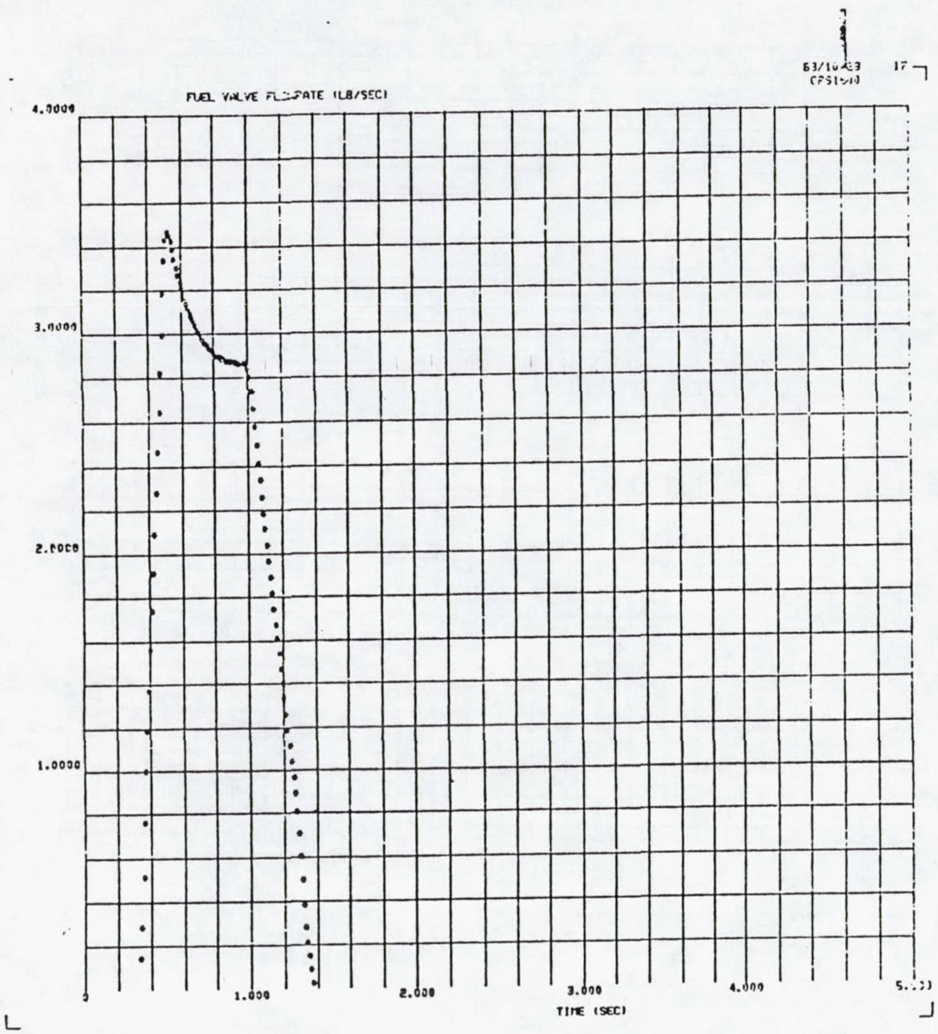
125.00
100.00
75.00
50.00
25.00
1.000
2.000
3.000
4.000
5.000
TIME (SEC)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2.0000
1.0000
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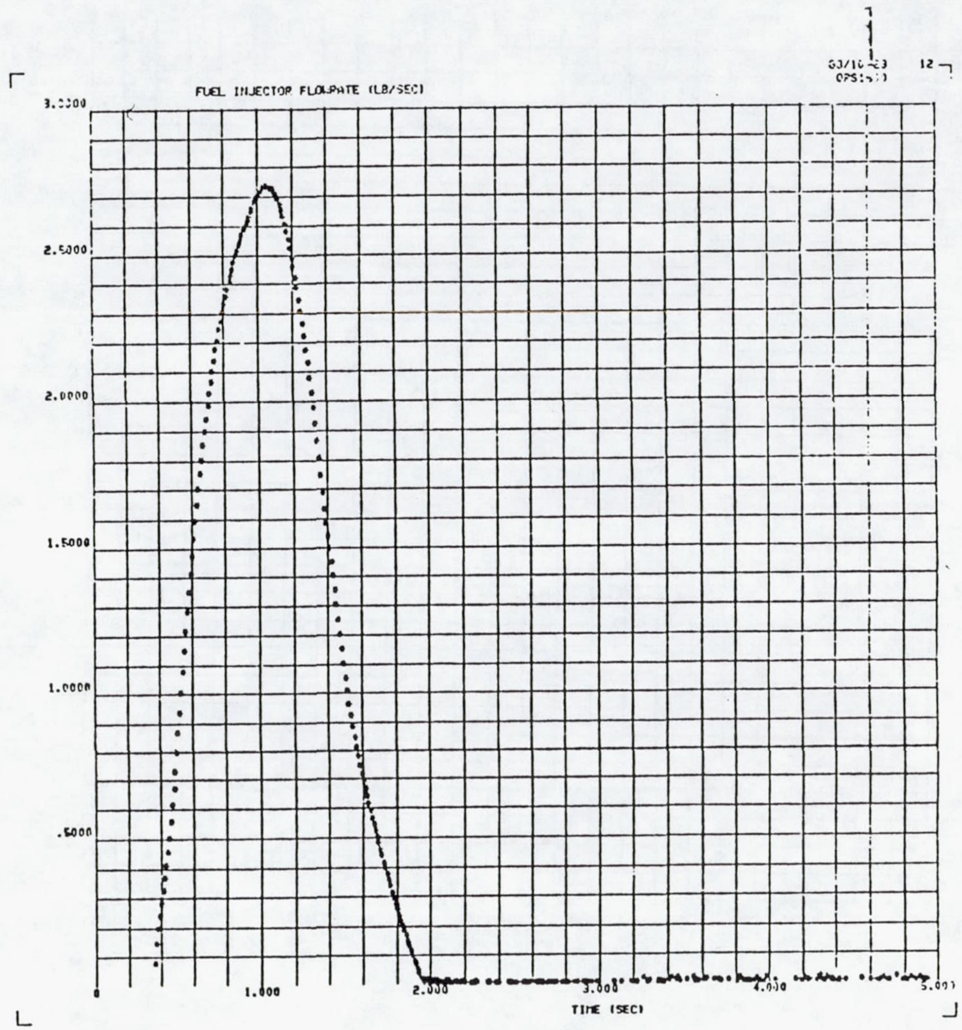
1.000
2.000
3.000
4.000
TIME (SEC)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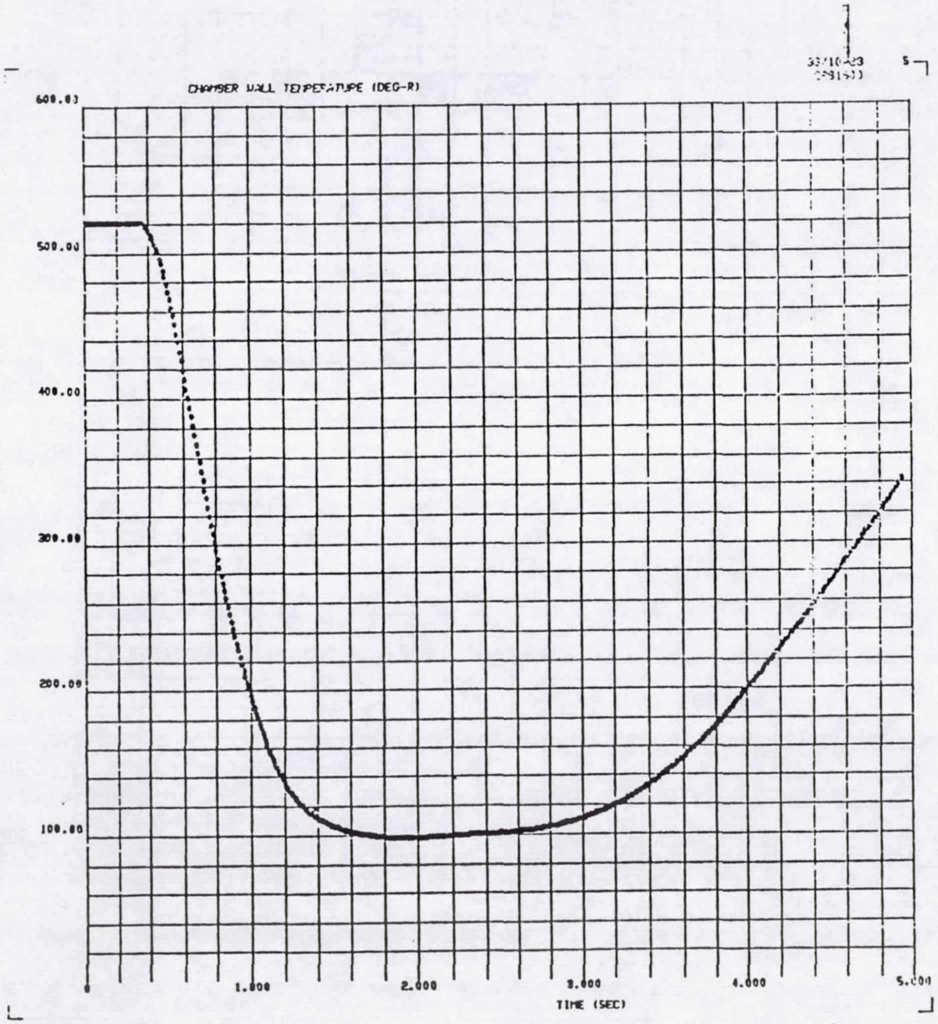
4.000
TIME (SEC)

091

096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300.00
200.00
100.00
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1.000
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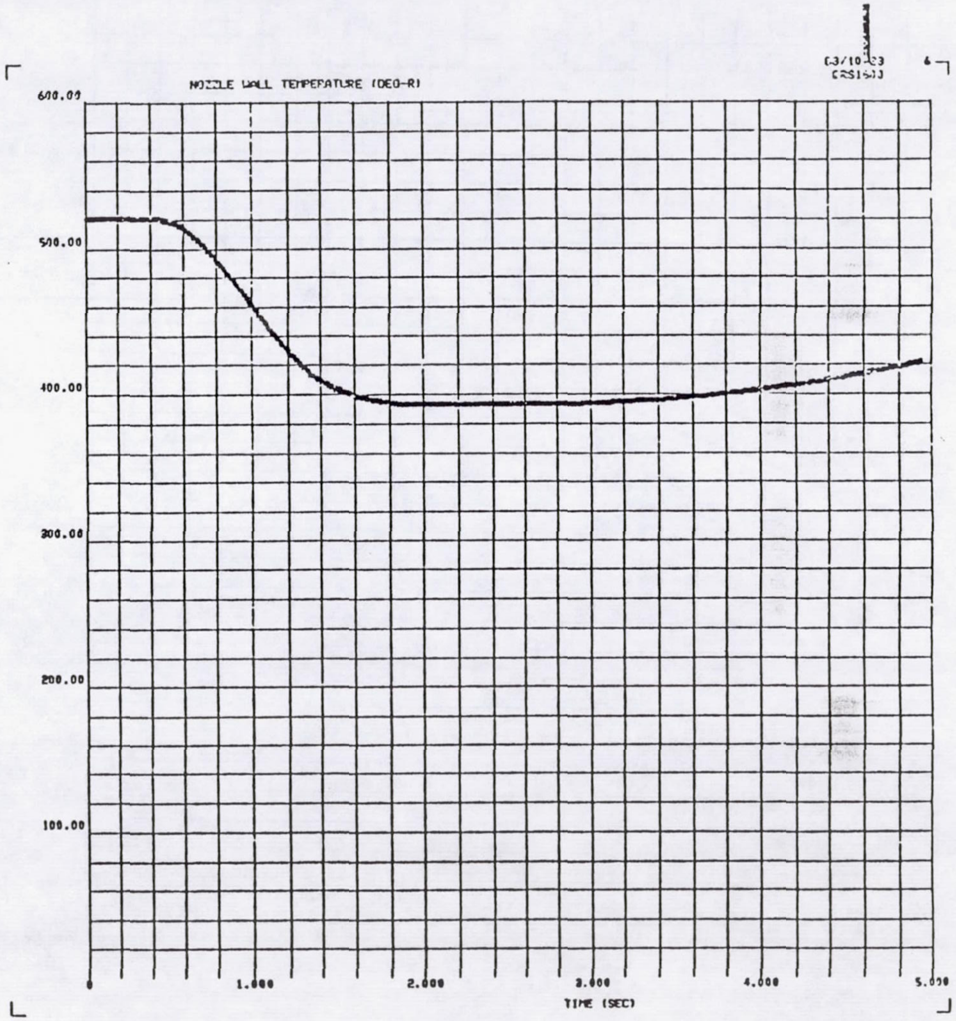
4.000
5.000
TIME (SEC)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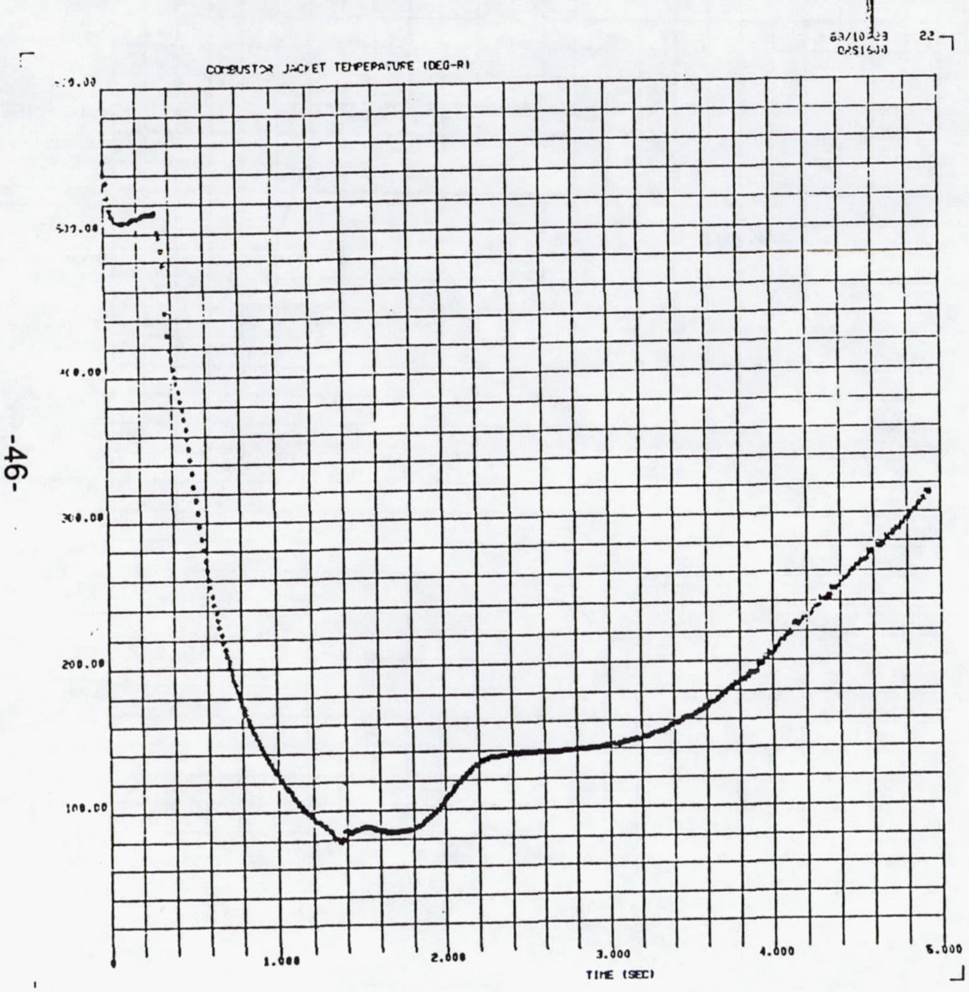
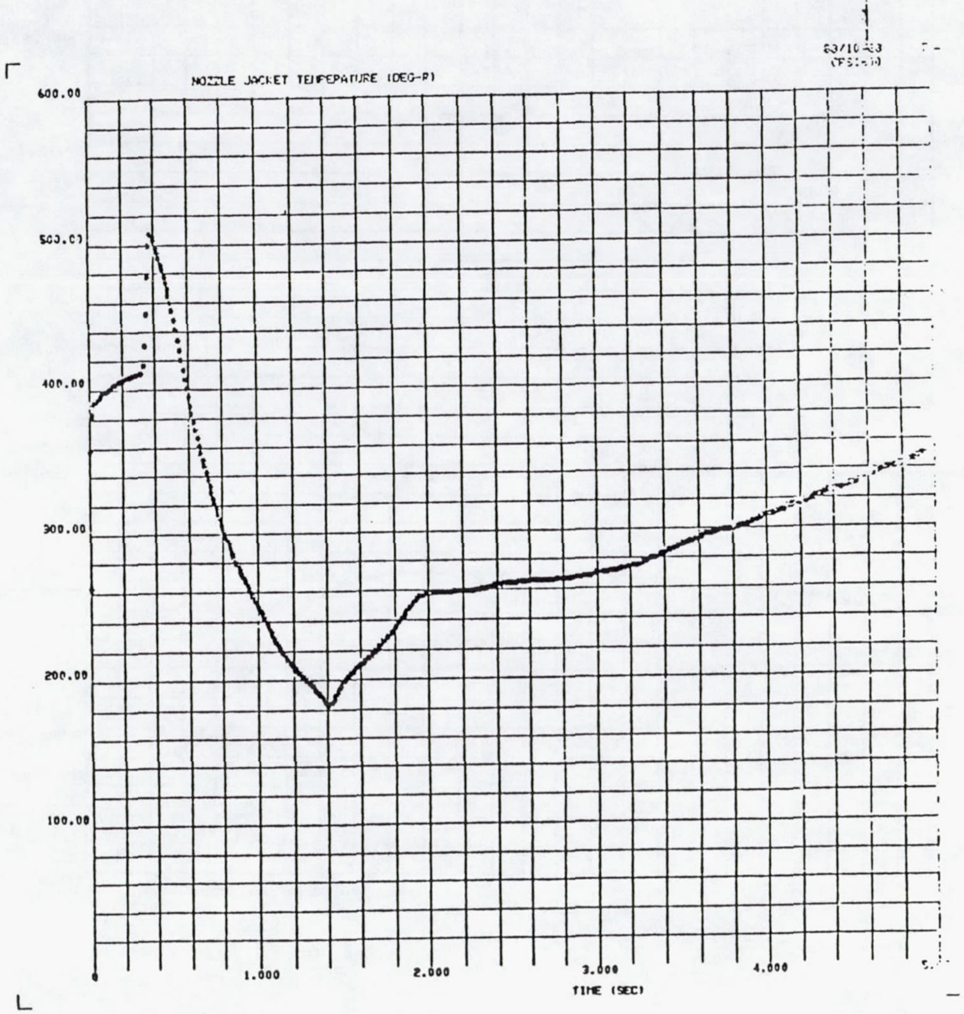
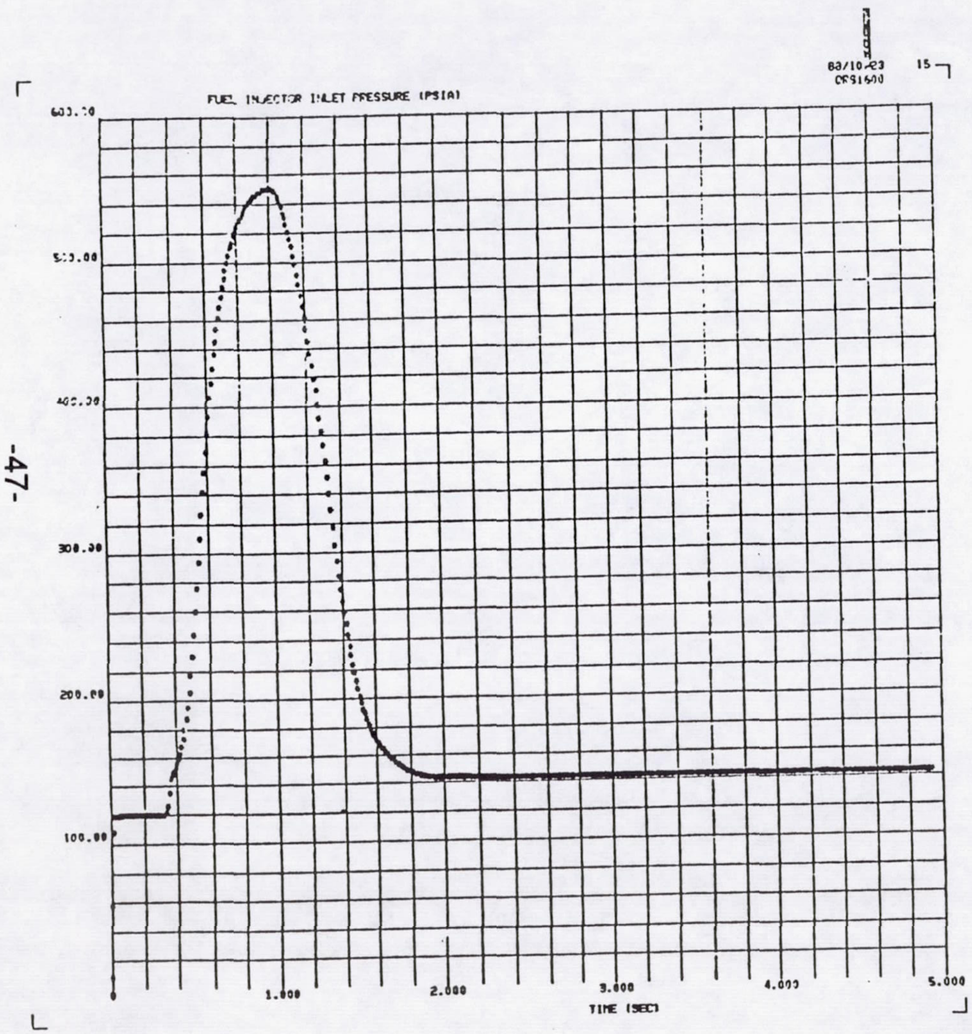
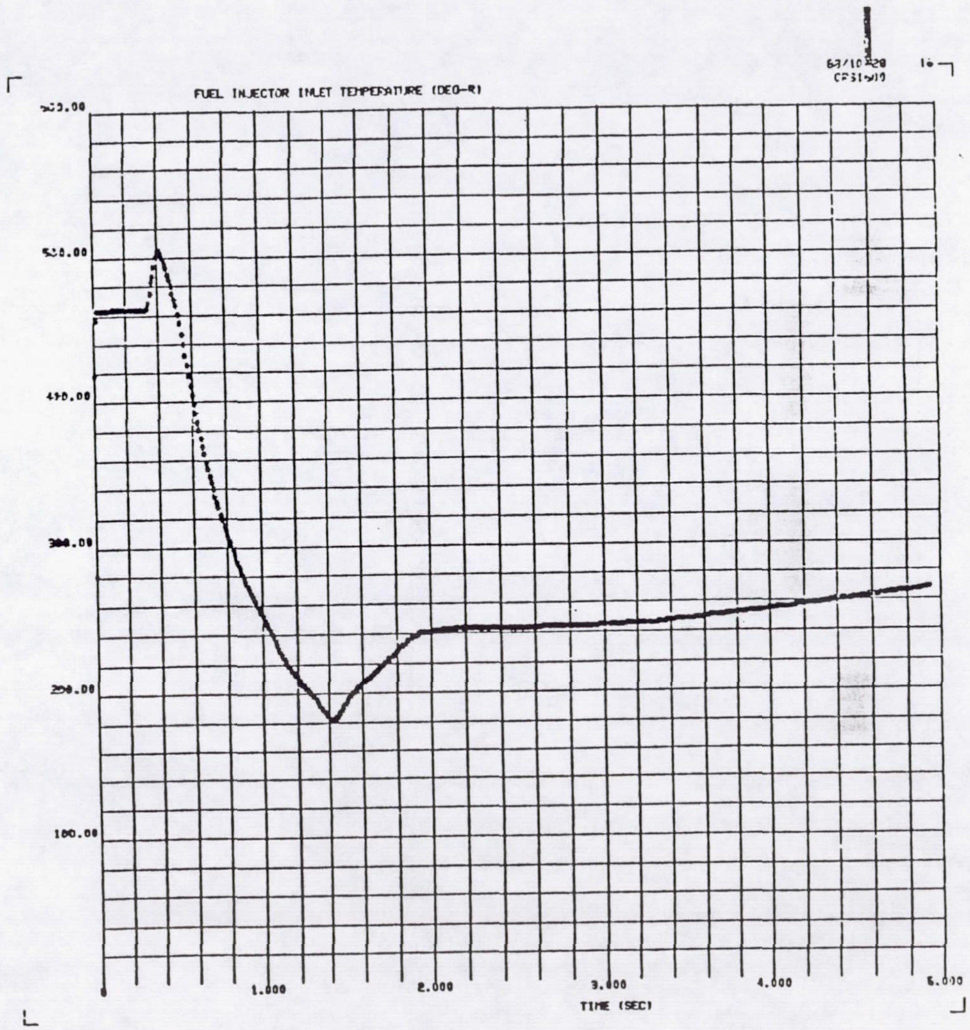
6
600.00
500.00
400.00
300.00
200.00
100.00
0
1.000
2.000
3.000
4.000
5.000
TIME (SEC)

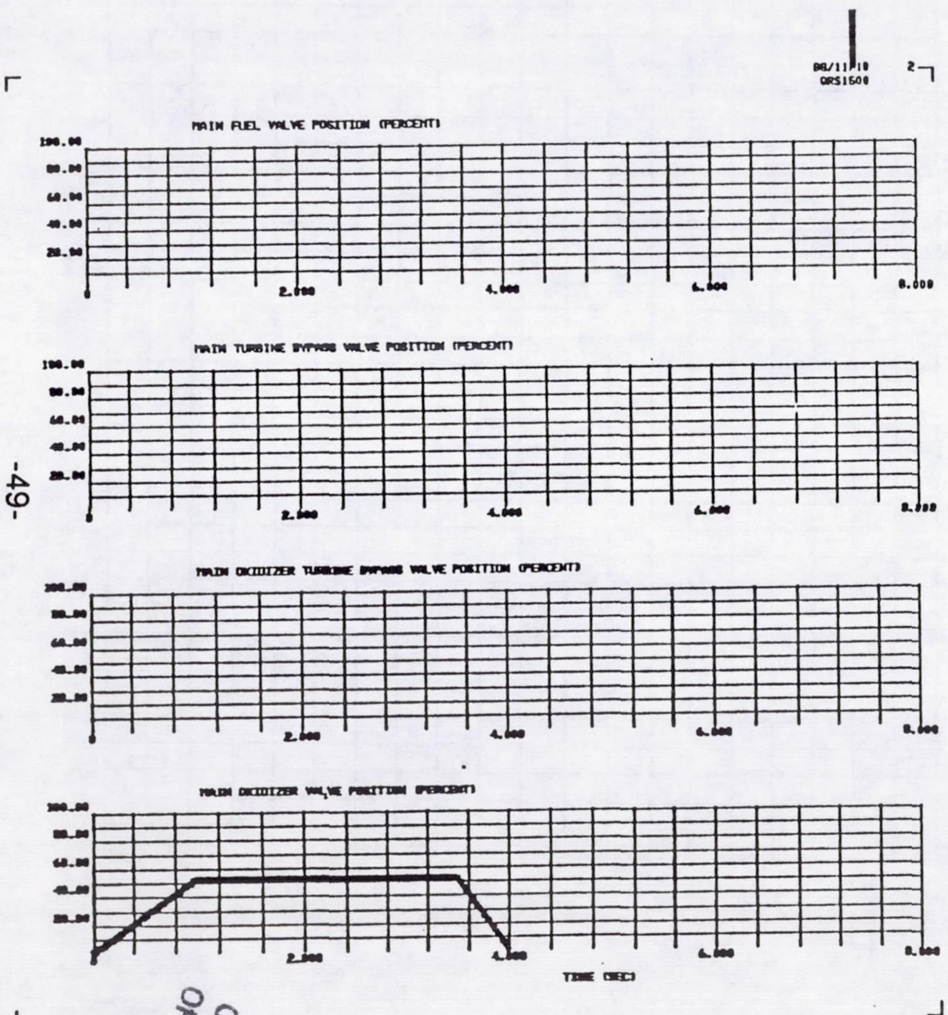

COMBUSTOR JACKET TEMPERATURE (DEG-R)
500.00
400.00
300.00
200.00
100.00
0
1.000
2.000
3.000
4.000
5.000
TIME (SEC)

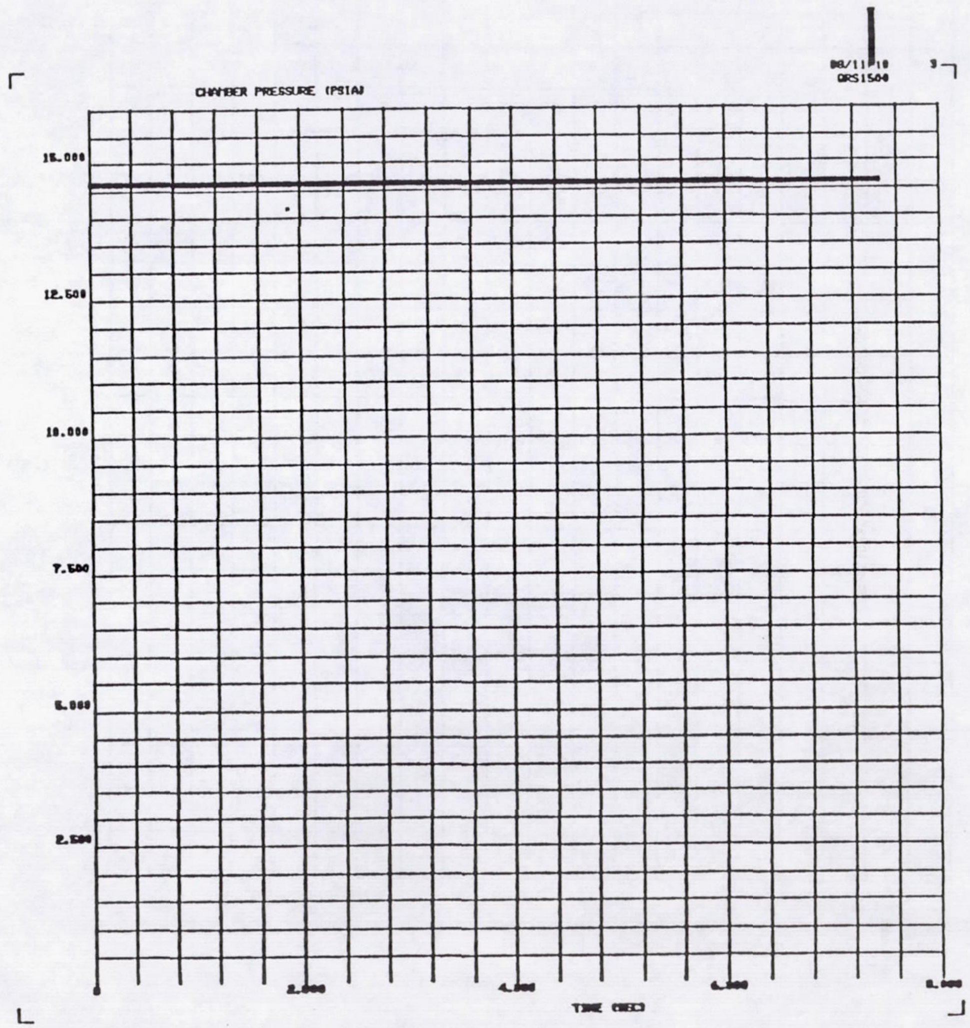

NOZZLE JACKET TEMPERATURE (DEG-R)
600.00
500.00
400.00
300.00
200.00
100.00
0
1.000
2.000
3.000
4.000
TIME (SEC)


FUEL INJECTOR INLET PRESSURE (PSIA)
15
600.00
500.00
400.00
300.00
200.00
100.00
1.000
2.000
3.000
4.000
5.000
TIME (SEC)


FUEL INJECTOR INLET TEMPERATURE (DEG-R)
16
500.00
400.00
300.00
200.00
100.00
1.000
2.000
3.000
4.000
5.000
TIME (SEC)

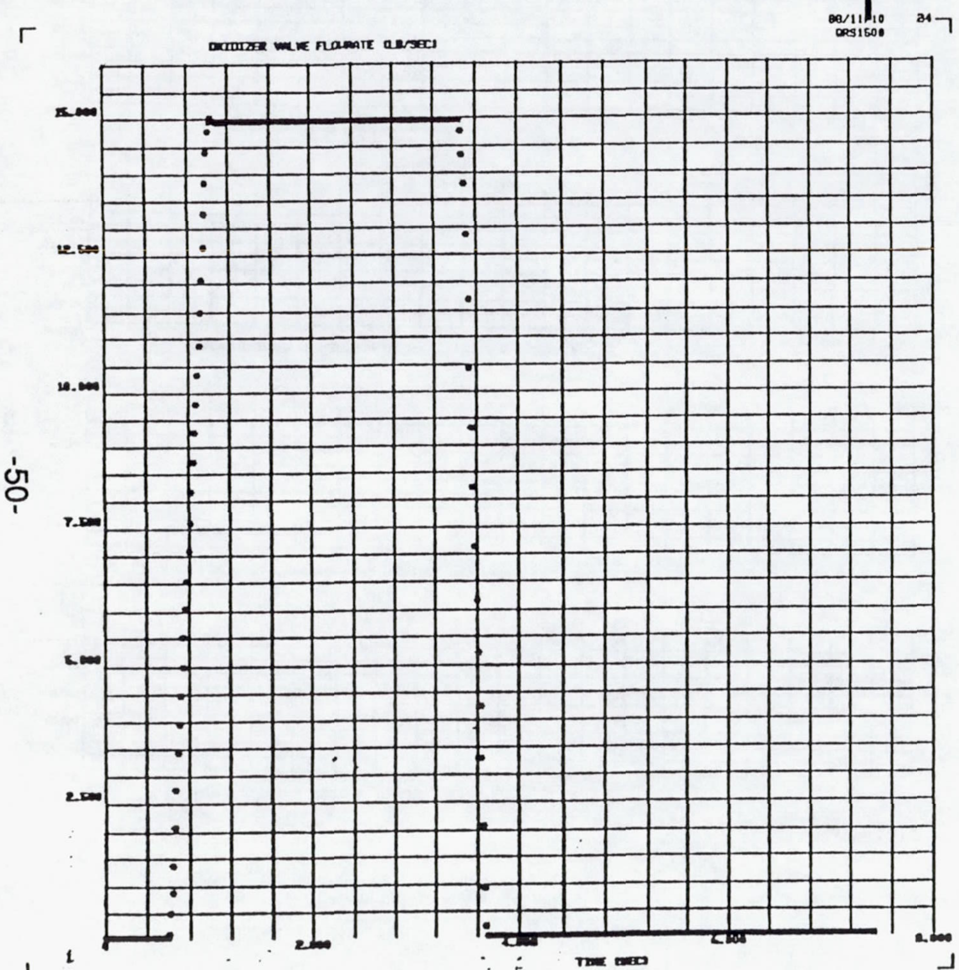
Oxidizer System Blowdown


88/11/10
QRS1500
2
MAIN FUEL VALVE POSITION (PERCENT)
MAIN TURBINE BYPASS VALVE POSITION (PERCENT)
MAIN OXIDIZER TURBINE BYPASS VALVE POSITION (PERCENT)
MAIN OXIDIZER VALVE POSITION (PERCENT)
2.000
4.000
6.000
8.000
TIME (SEC)

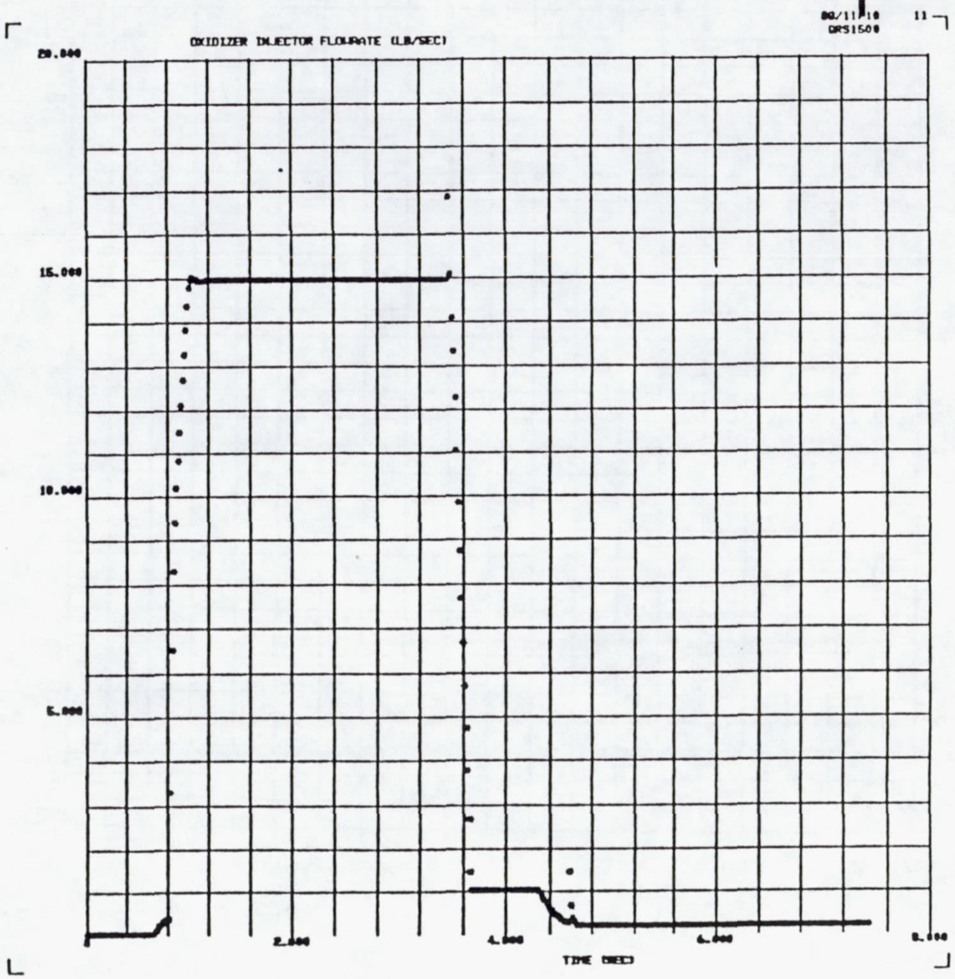

88/11/10
QRS1500
3
CHAMBER PRESSURE (PSIA)
15.000
12.500
10.000
7.500
5.000
2.500
2.000
4.000
6.000
8.000
TIME (SEC)

851

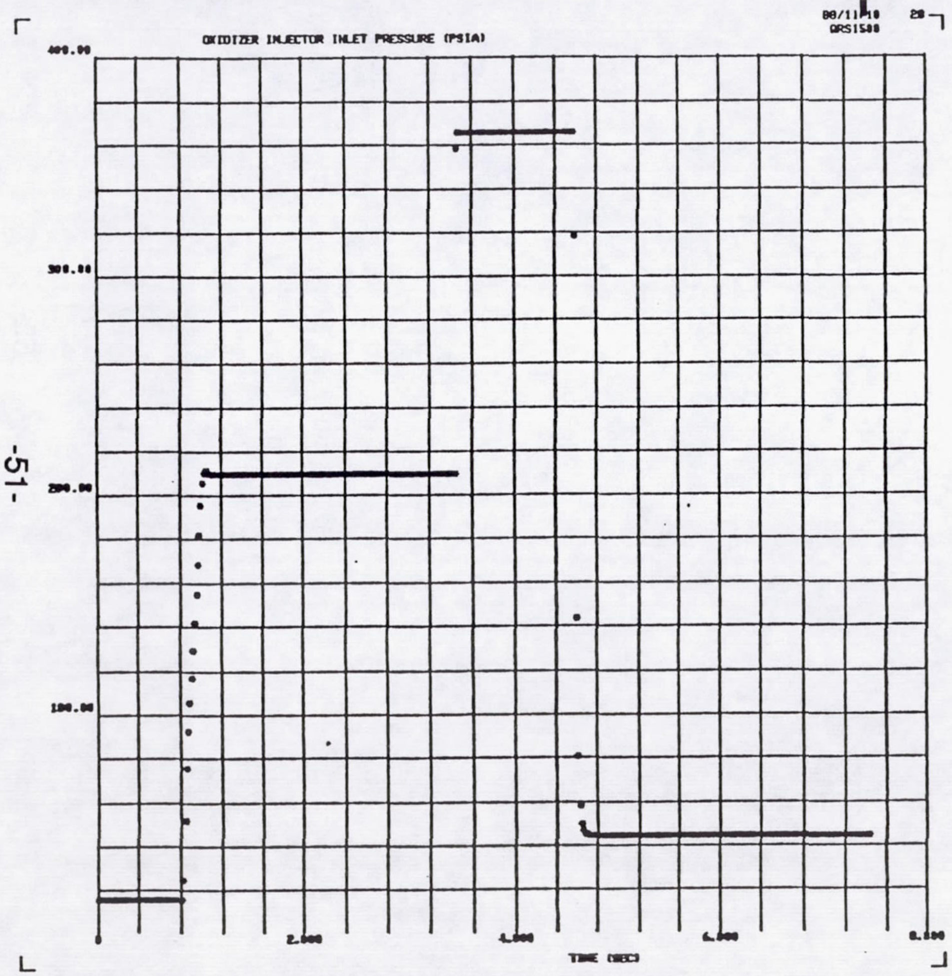
853


88/11/10
ORS1500
24
OXIDIZER VALVE FLOWRATE (LB/SEC)
15.000
12.500
10.000
7.500
5.000
2.500
2.000
4.000
6.000
8.000
TIME (SEC)

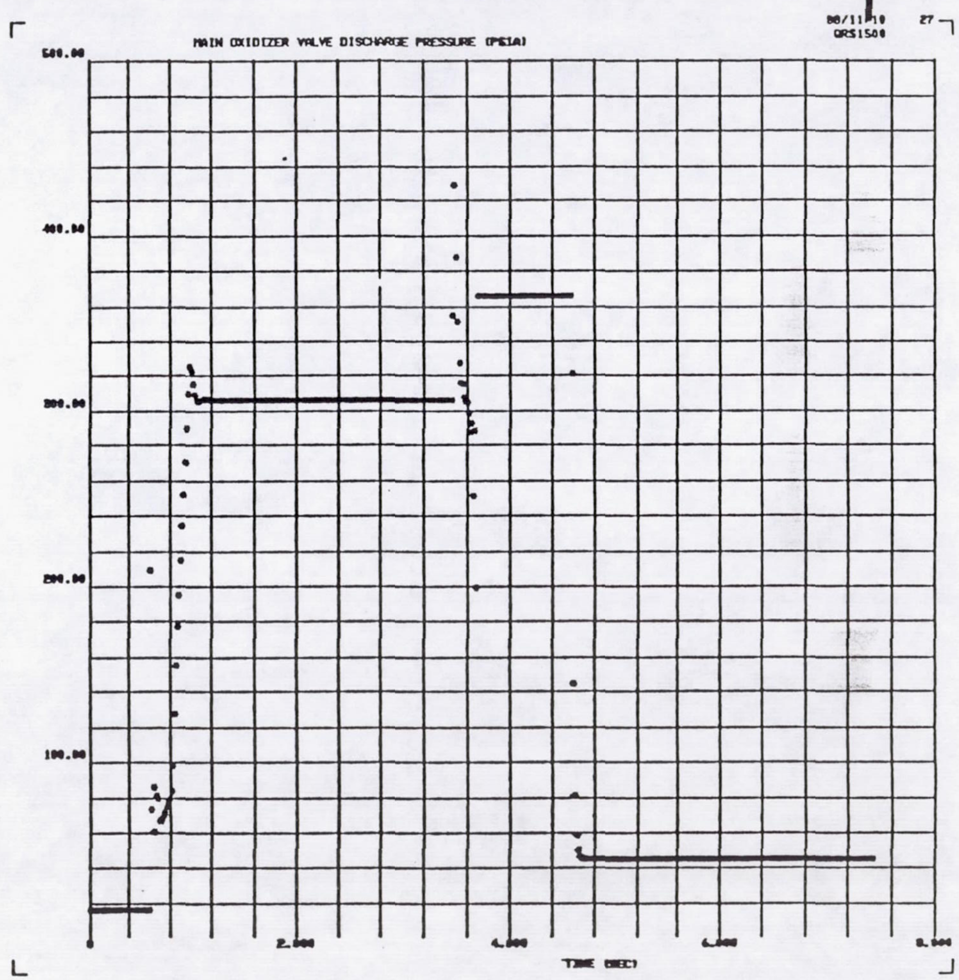
332


88/11/10
ORS1500
11
OXIDIZER INJECTOR FLOWRATE (LB/SEC)
20.000
15.000
10.000
5.000
2.000
4.000
6.000
8.000
TIME (SEC)

845

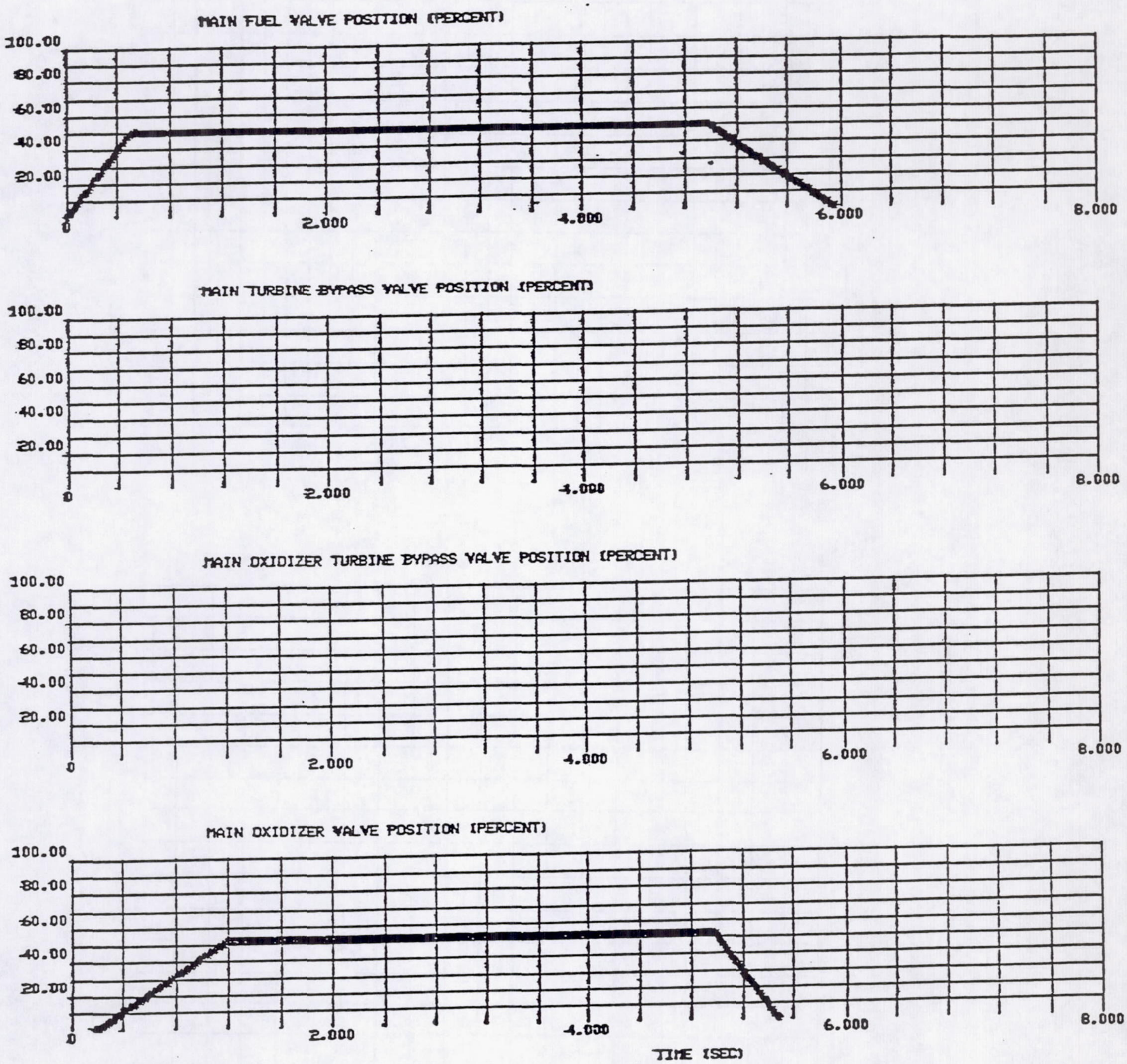

88/11/10
QRS1500
28
OXIDIZER INJECTOR INLET PRESSURE (PSIA)
400.00
300.00
200.00
100.00
0
2.000
4.000
6.000
8.000
TIME (SEC)

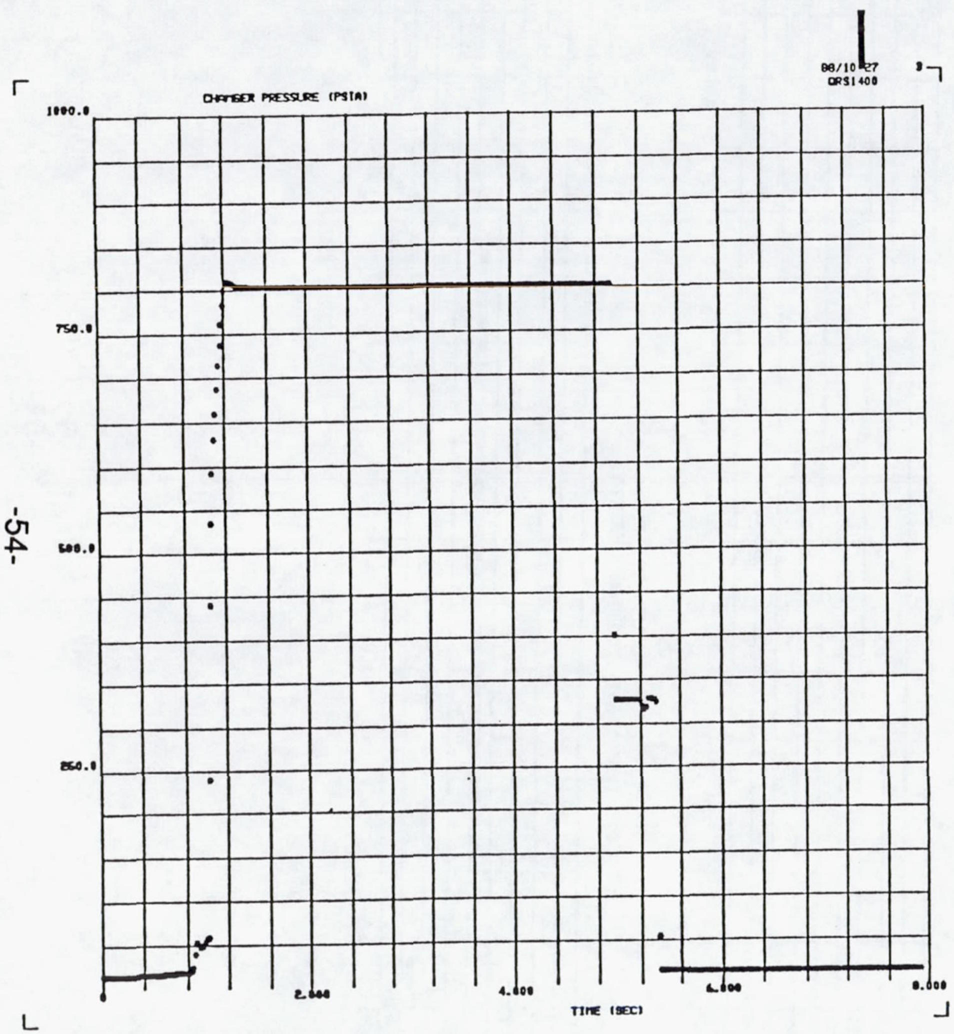
828


88/11/10
QRS1500
27
MAIN OXIDIZER VALVE DISCHARGE PRESSURE (PSIA)
500.00
400.00
300.00
200.00
100.00
0
2.000
4.000
6.000
8.000
TIME (SEC)

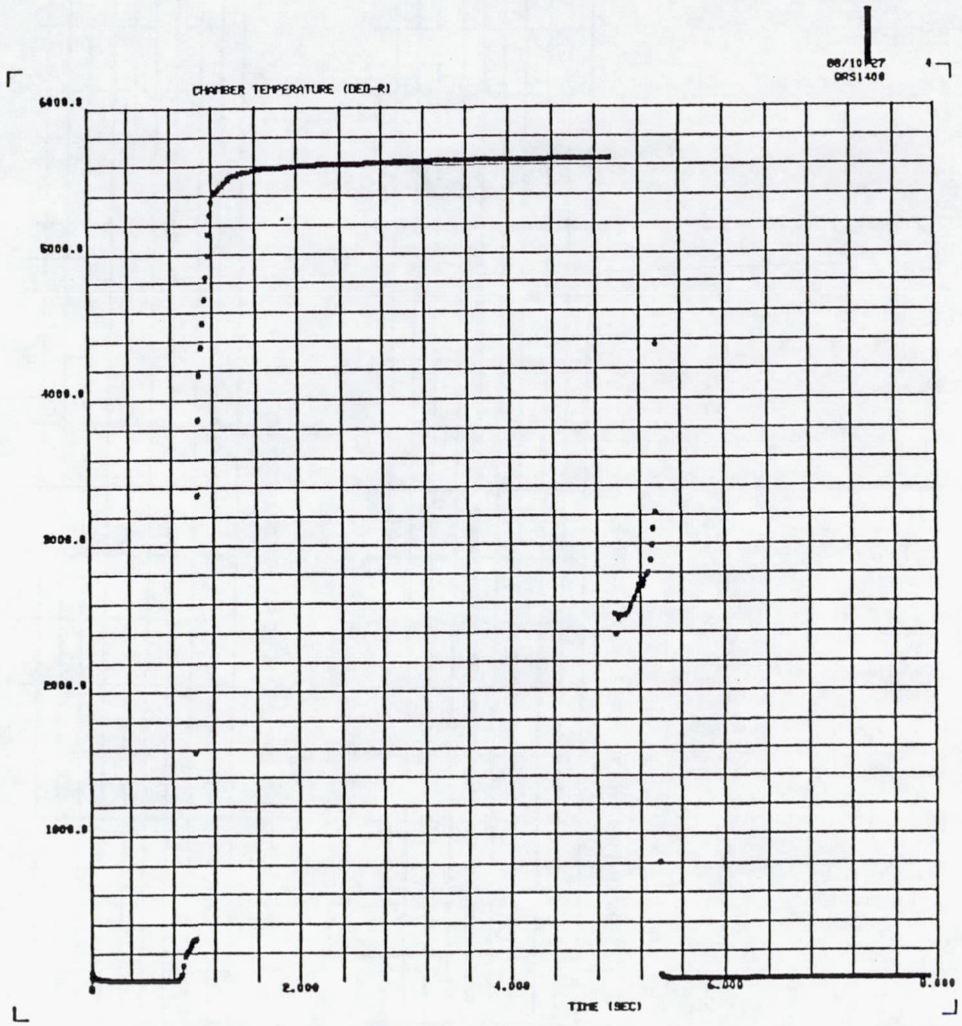
829

Start - Cutoff at Pc=800 psia, MR=5

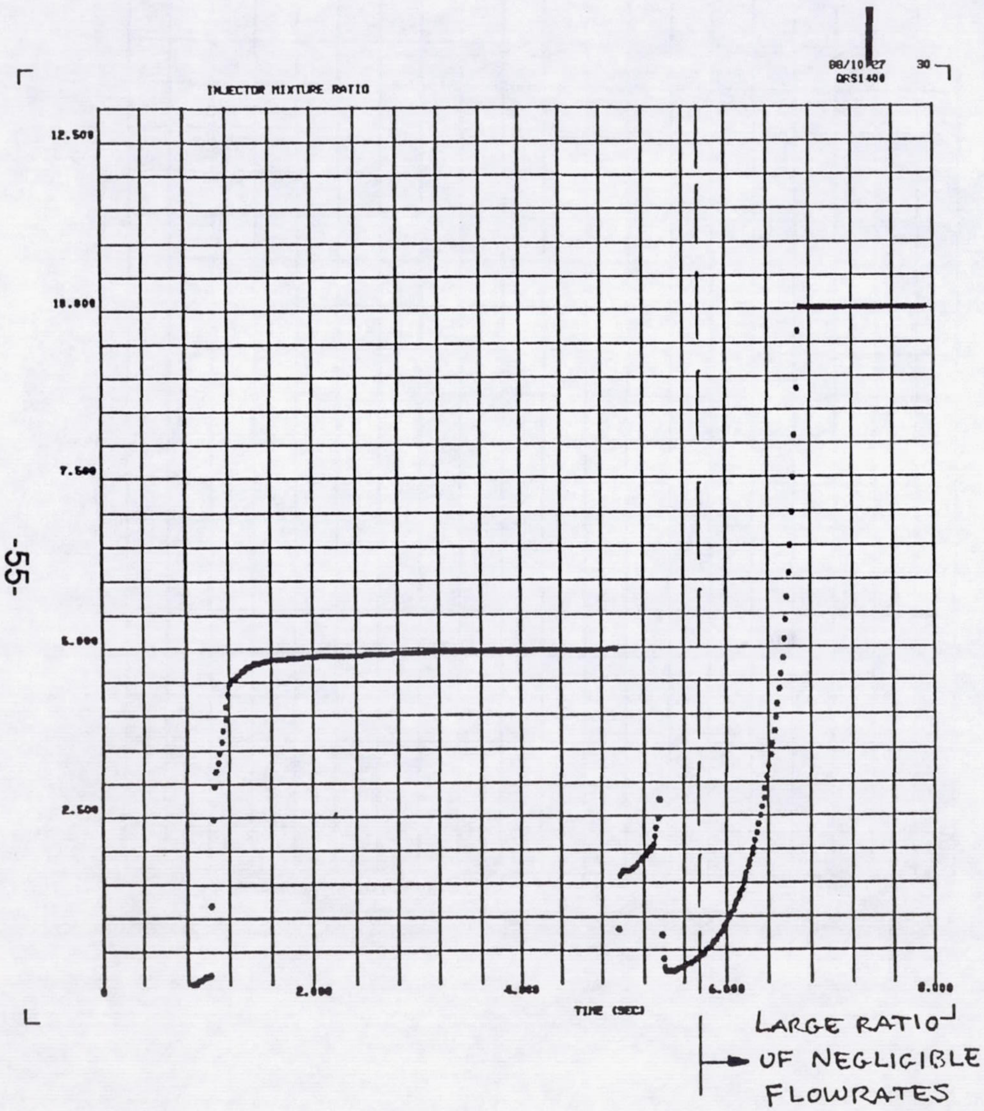

MAIN FUEL VALVE POSITION (PERCENT)
100.00
80.00
60.00
40.00
20.00
0
2.000
4.000
6.000
8.000
MAIN TURBINE BYPASS VALVE POSITION (PERCENT)
MAIN OXIDIZER TURBINE BYPASS VALVE POSITION (PERCENT)
MAIN OXIDIZER VALVE POSITION (PERCENT)
TIME (SEC)

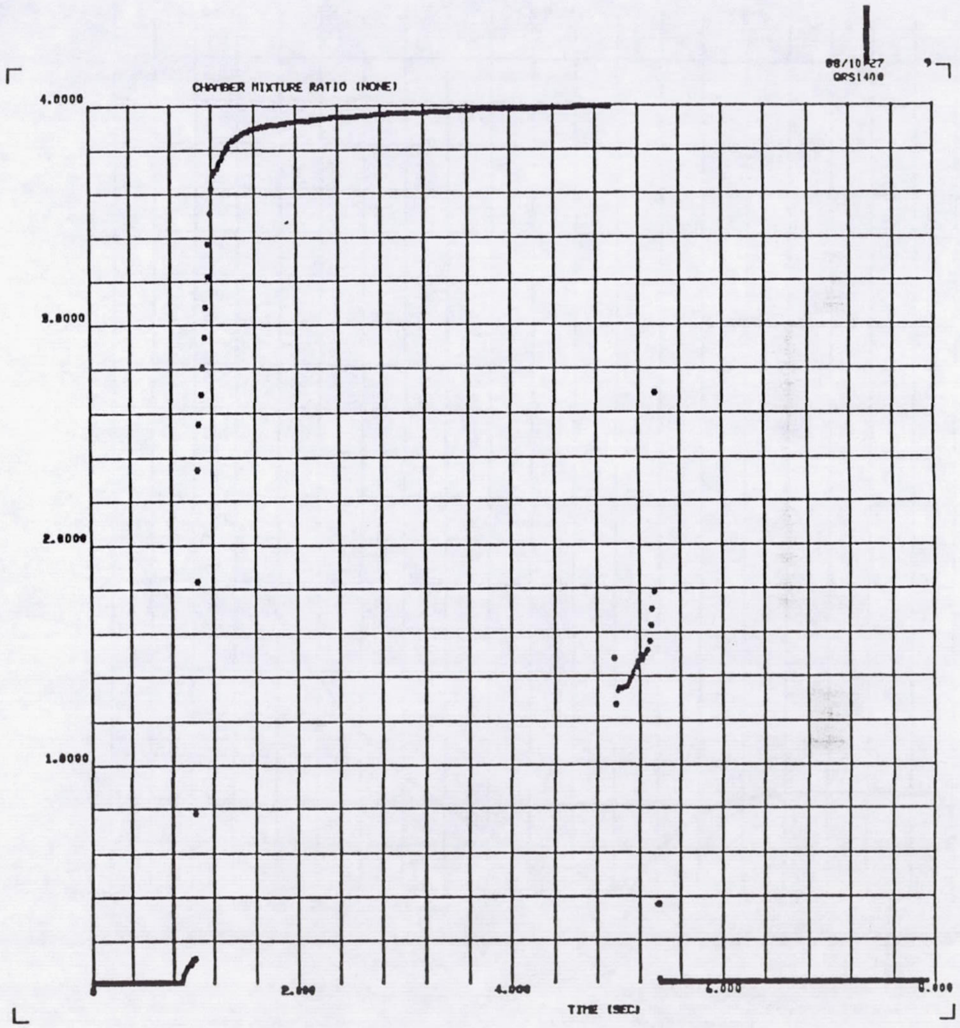

88/10/27
QRS1400
3
CHAMBER PRESSURE (PSIA)
1000.0
750.0
500.0
250.0
0
2.000
4.000
6.000
8.000
TIME (SEC)

723


88/10/27
QRS1400
4
CHAMBER TEMPERATURE (DEG-R)
6000.0
5000.0
4000.0
3000.0
2000.0
1000.0
0
2.000
4.000
6.000
8.000
TIME (SEC)

722

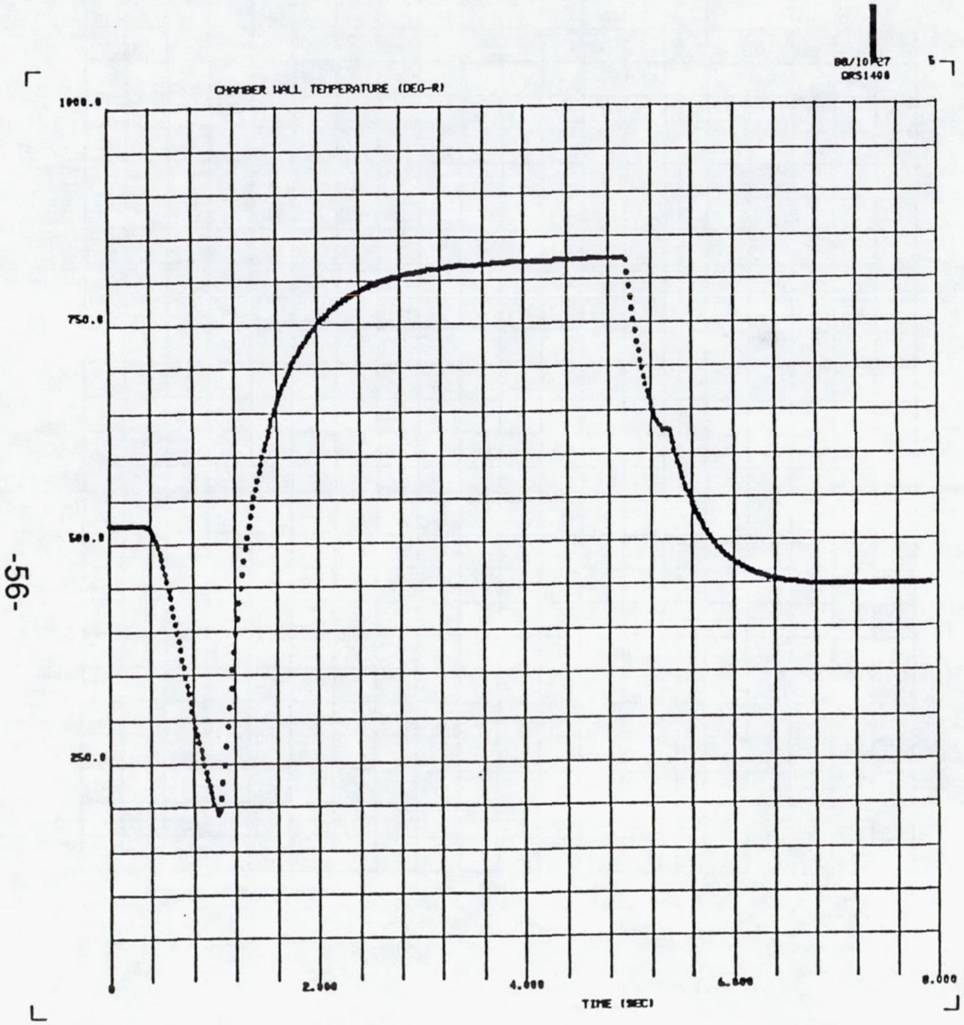

08/10/27
QRS1400
30
INJECTOR MIXTURE RATIO
12.500
10.000
7.500
5.000
2.500
0
2.000
4.000
6.000
8.000
TIME (SEC)
LARGE RATIO
OF NEGLIGIBLE
FLOWRATES


08/10/27
QRS1400
9
CHAMBER MIXTURE RATIO (NONE)
4.0000
3.0000
2.0000
1.0000
0
2.000
4.000
6.000
8.000
TIME (SEC)

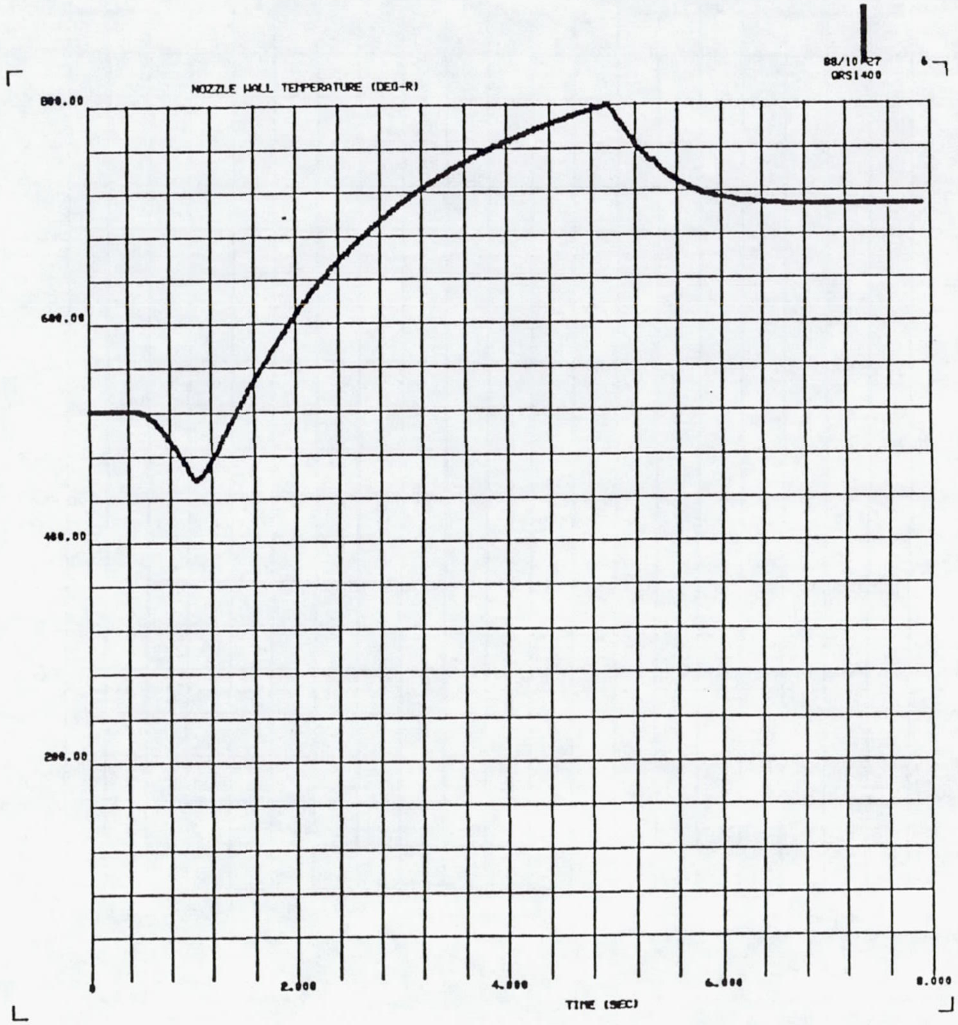
-55-

696

717



88/10/27
QRS1400
CHAMBER WALL TEMPERATURE (DEG-R)
1000.0
750.0
500.0
250.0
0
2.000
4.000
6.000
8.000
TIME (SEC)

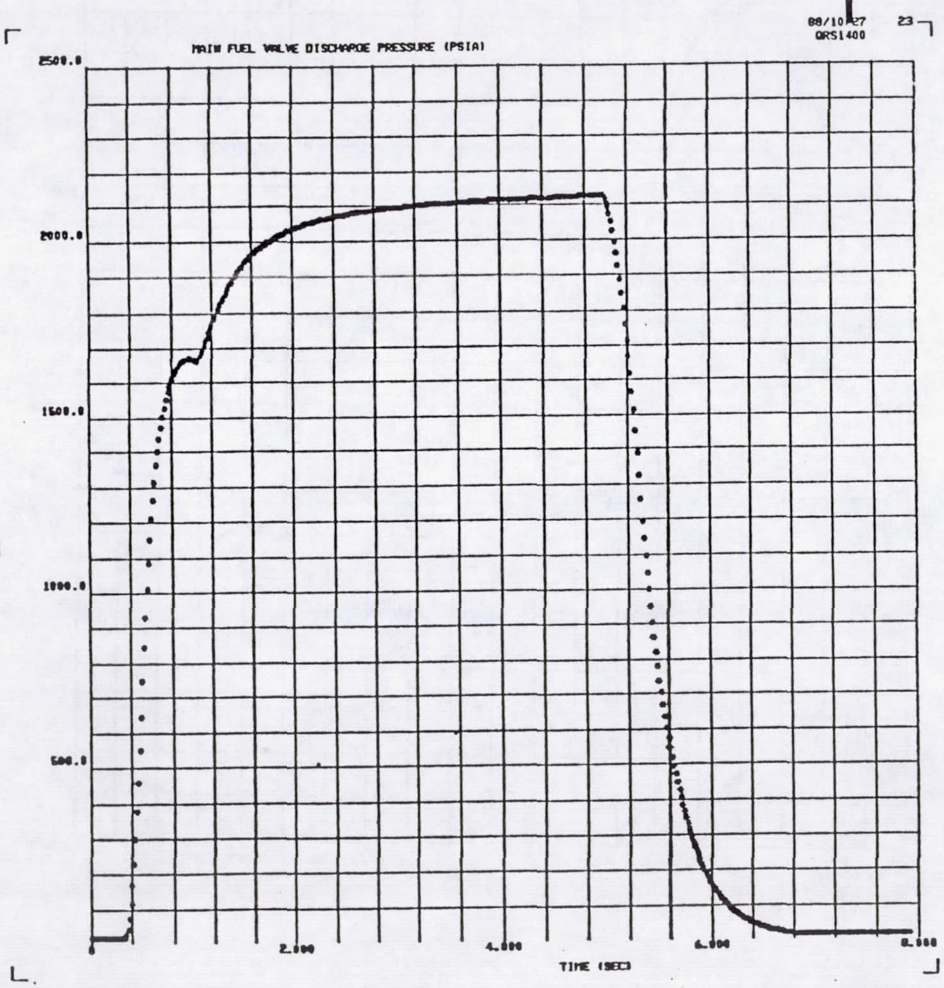


88/10/27
QRS1400
NOZZLE WALL TEMPERATURE (DEG-R)
800.00
600.00
400.00
200.00
0
2.000
4.000
6.000
8.000
TIME (SEC)

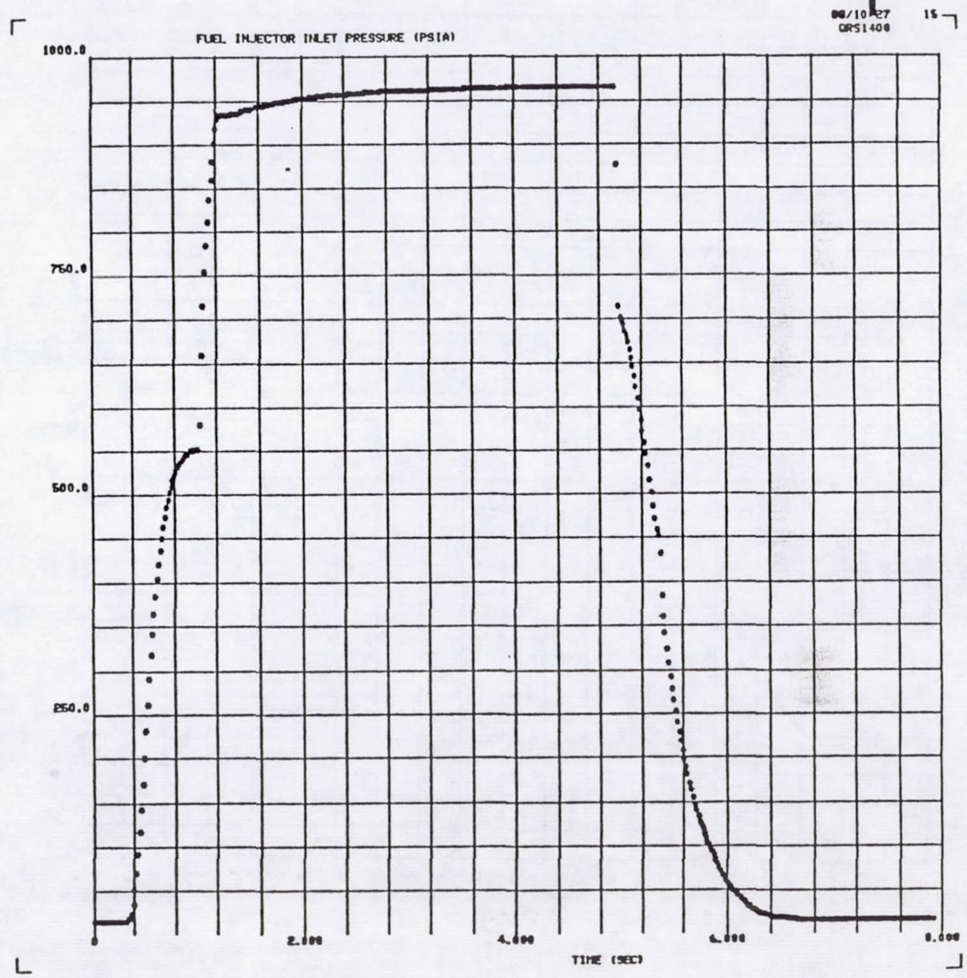
721

720

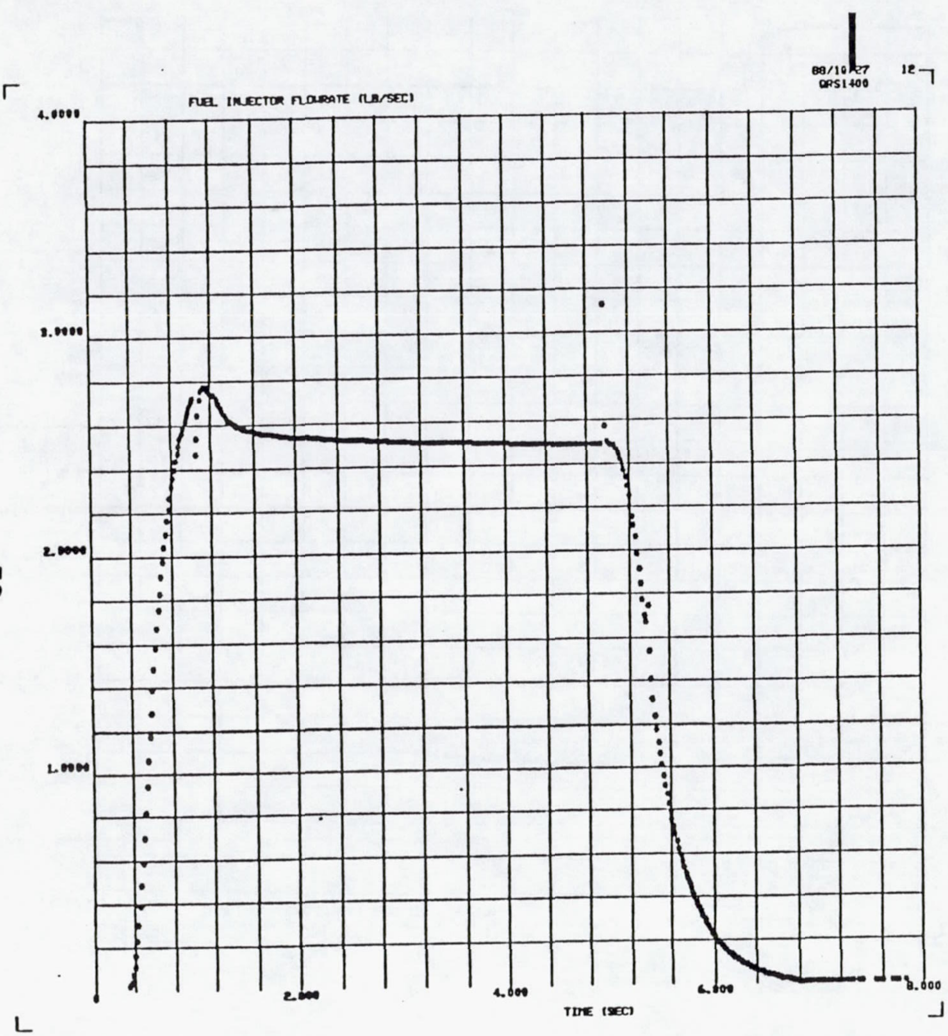
C5

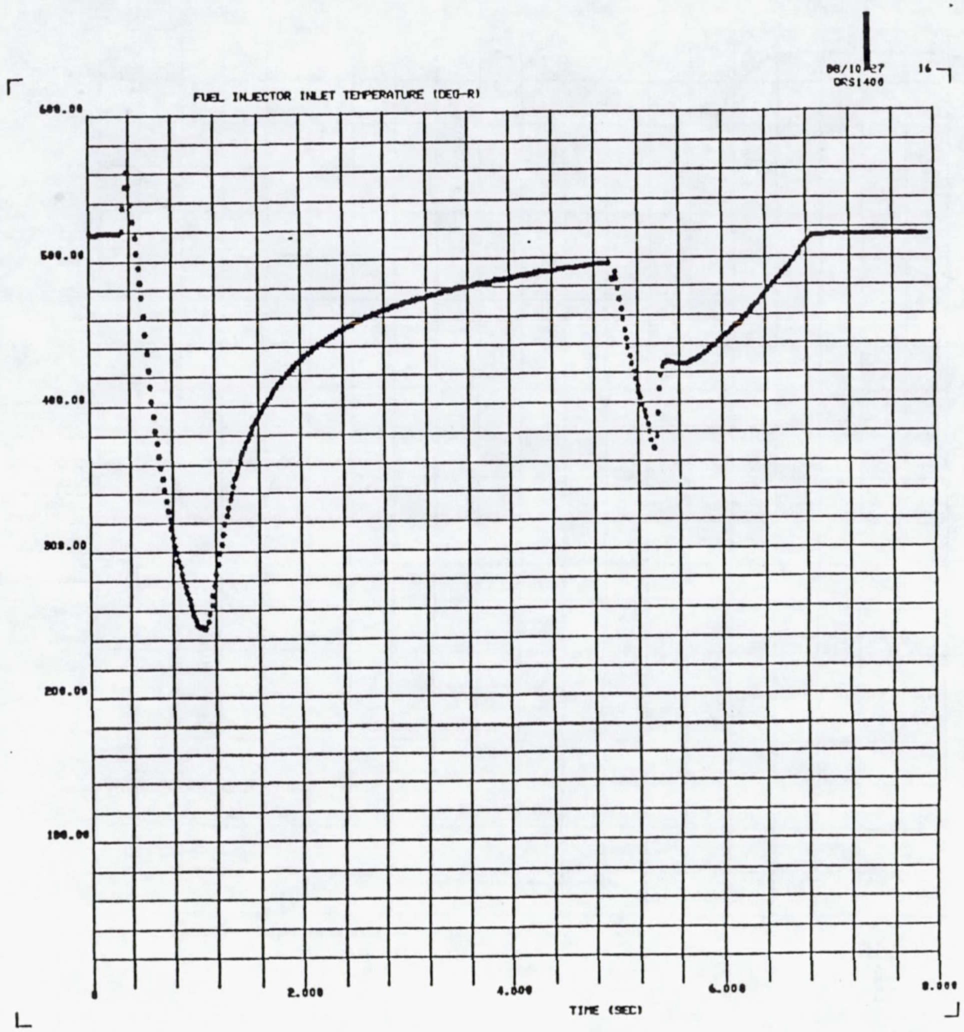

88/10/27 23
QRS1400
MAIN FUEL VALVE DISCHARGE PRESSURE (PSIA)
2500.0
2000.0
1500.0
1000.0
500.0
0
2.000
4.000
6.000
8.000
TIME (SEC)

703


88/10/27 15
QRS1400
FUEL INJECTOR INLET PRESSURE (PSIA)
1000.0
750.0
500.0
250.0
0
2.000
4.000
6.000
8.000
TIME (SEC)

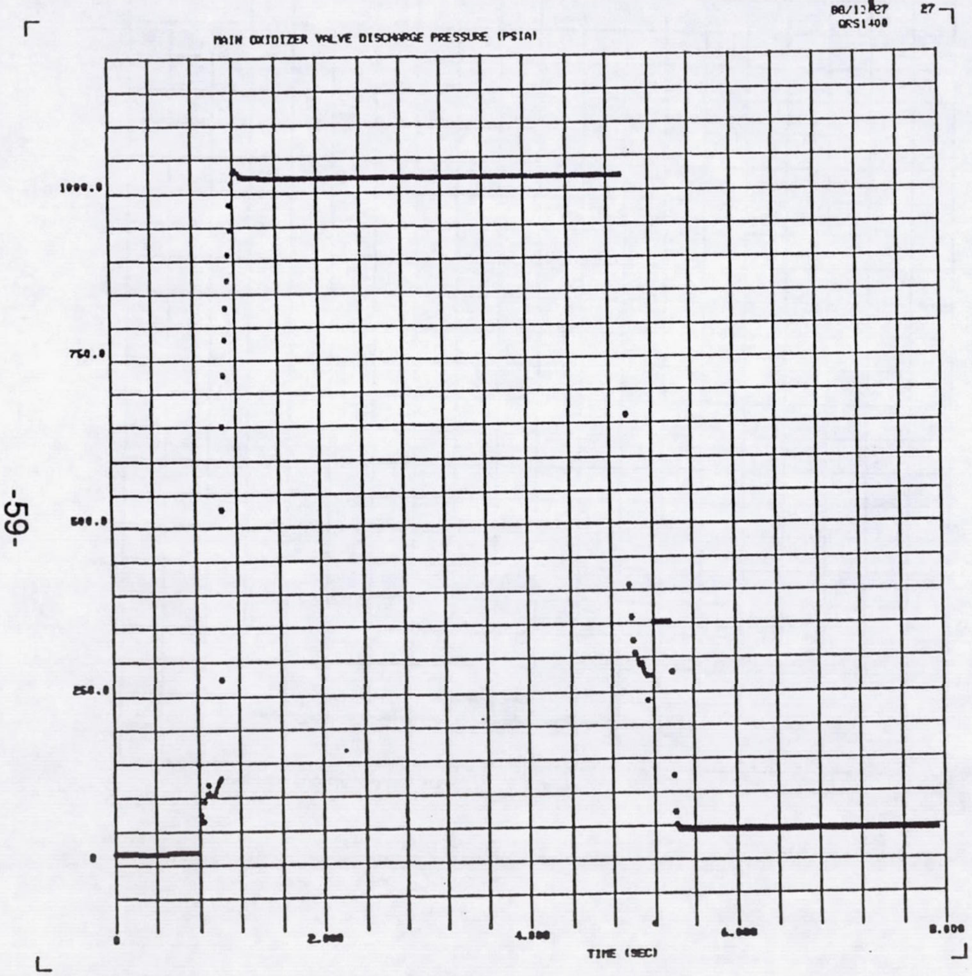
711


88/10/27
QRS1400
12
FUEL INJECTOR FLOWRATE (LB/SEC)
4.0000
3.0000
2.0000
1.0000
0
2.000
4.000
6.000
8.000
TIME (SEC)

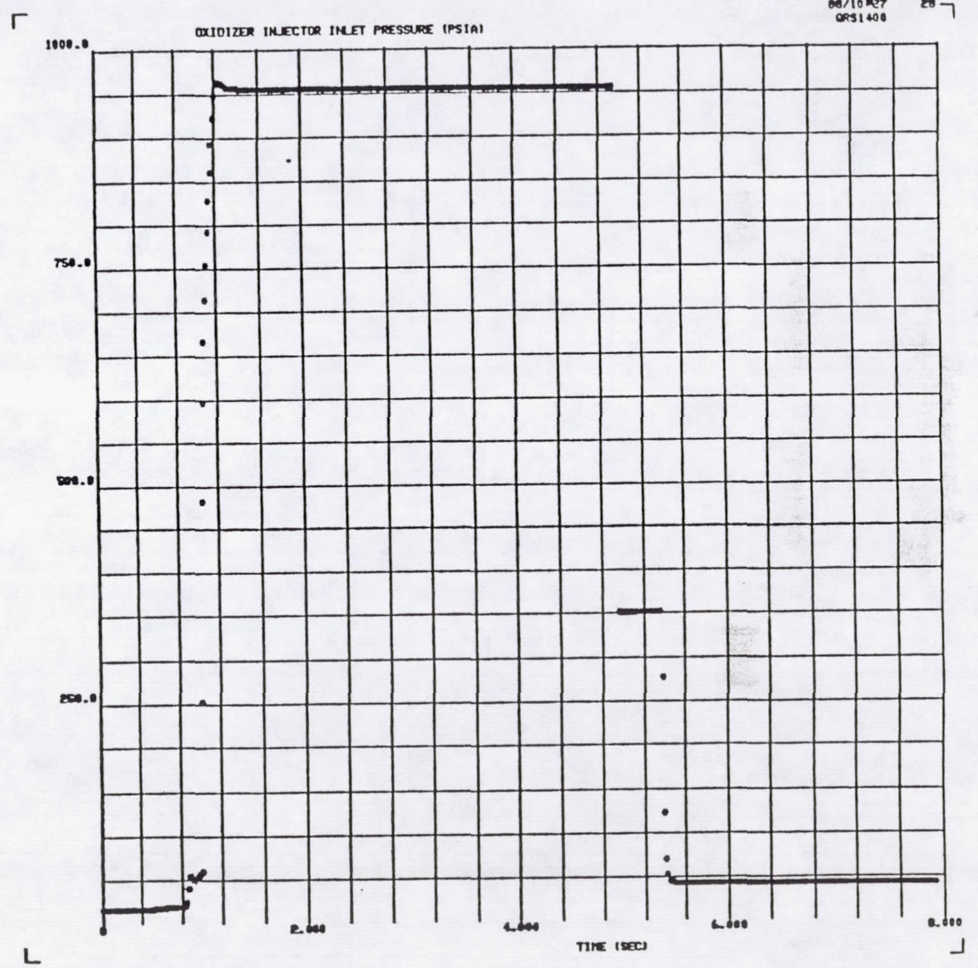

88/10/27
QRS1400
16
FUEL INJECTOR INLET TEMPERATURE (DEG-R)
600.00
500.00
400.00
300.00
200.00
100.00
0
2.000
4.000
6.000
8.000
TIME (SEC)

714

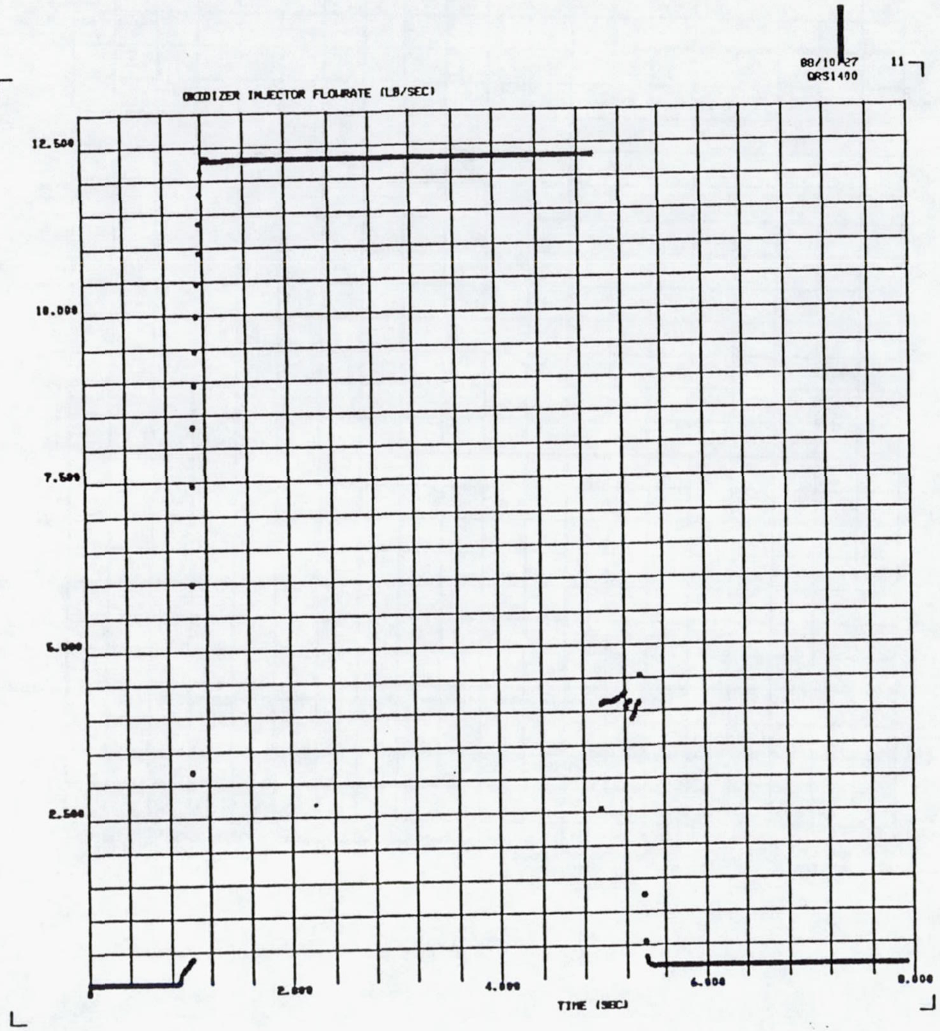
710


08/10/27 27
QRS1400
MAIN OXIDIZER VALVE DISCHARGE PRESSURE (PSIA)
1000.0
750.0
500.0
250.0
0
2.000
4.000
6.000
8.000
TIME (SEC)

699


08/10/27 28
QRS1400
OXIDIZER INJECTOR INLET PRESSURE (PSIA)
1000.0
750.0
500.0
250.0
2.000
4.000
6.000
8.000
TIME (SEC)

698

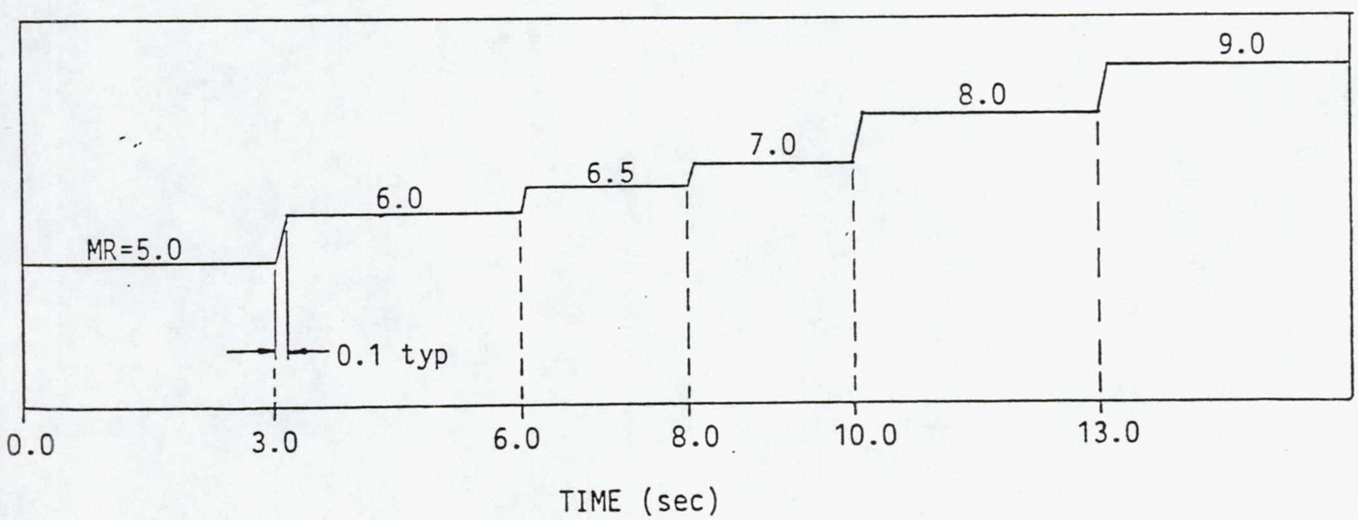

88/10/27
QRS1400
11
OXIDIZER INJECTOR FLOWRATE (LB/SEC)
12.500
10.000
7.500
5.000
2.500
2.000
4.000
6.000
8.000
TIME (SEC)

715

APPENDIX II

II. Steady State Mixture Ratio Variation Simulation Runs

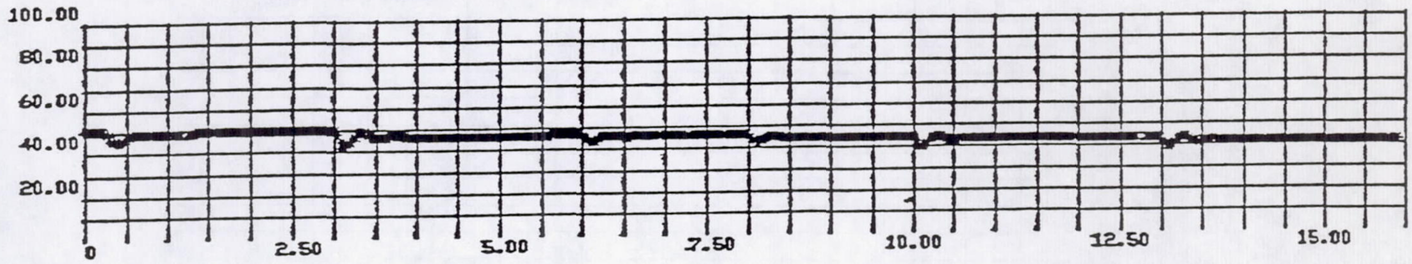
Closed-Loop Mixture Ratio Variations at Pc=800 psia



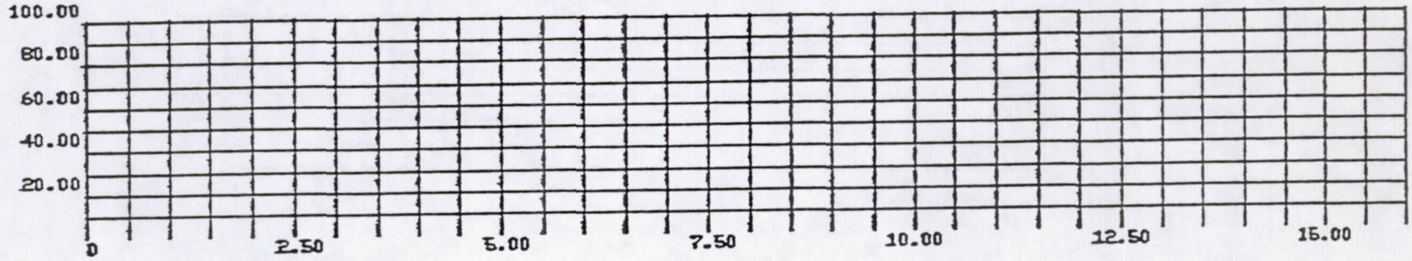
Injector Mixture Ratio Command

A1

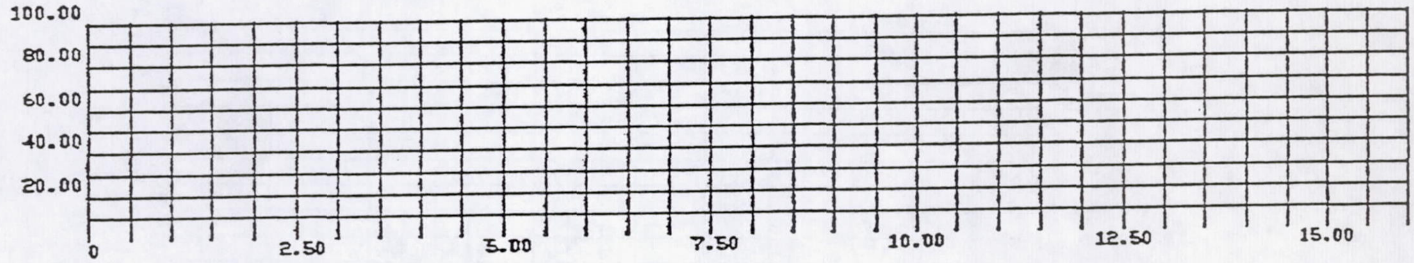
MAIN FUEL VALVE POSITION (PERCENT)



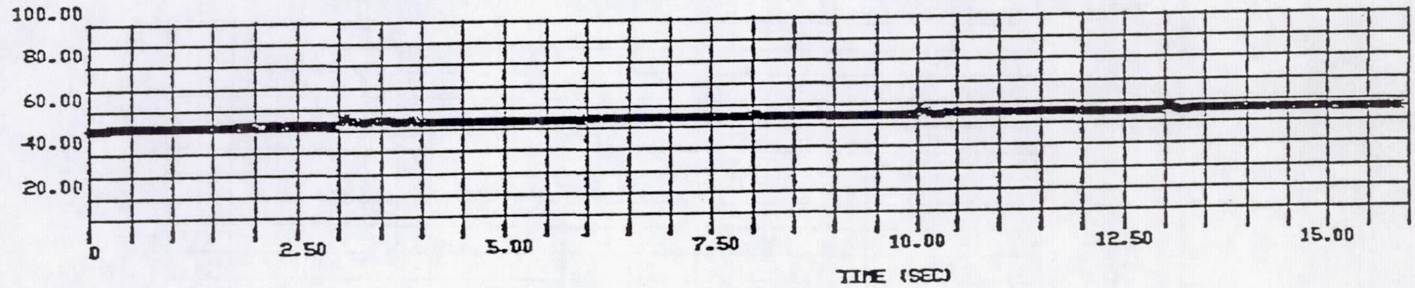
MAIN TURBINE BYPASS VALVE POSITION (PERCENT)

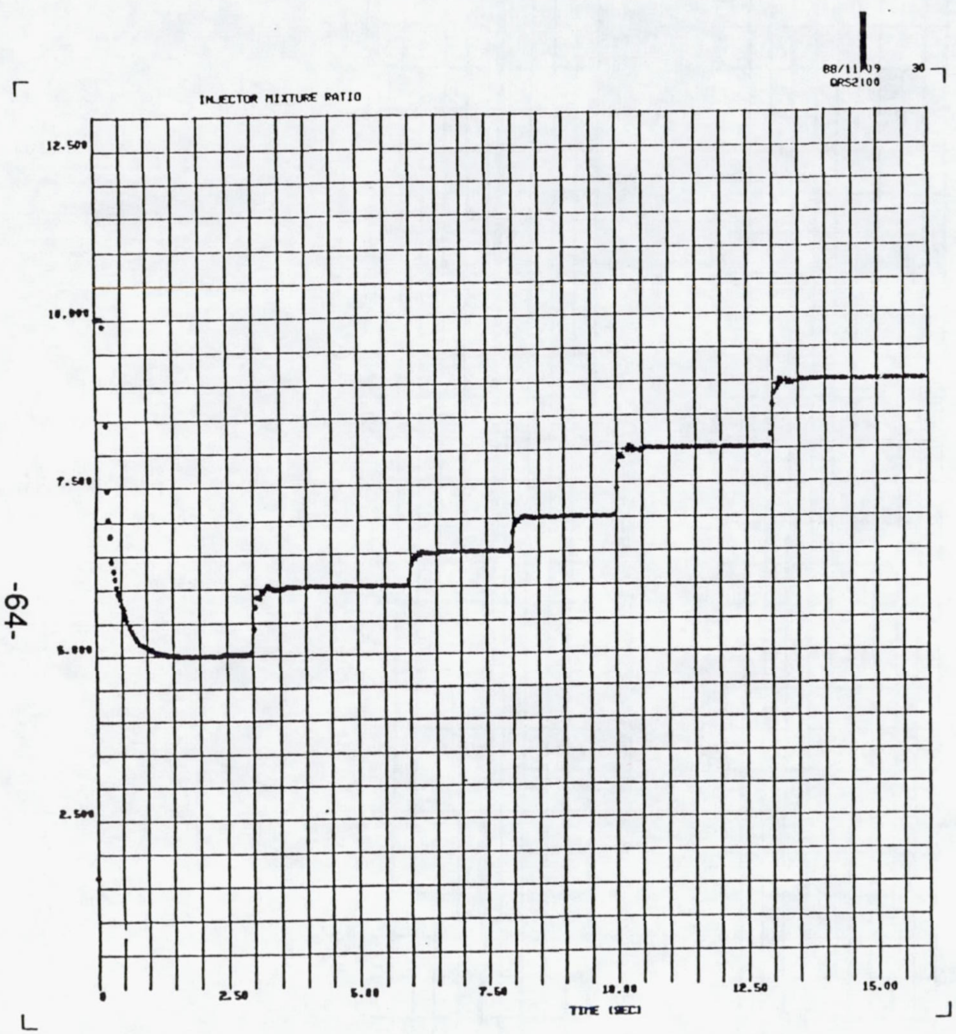


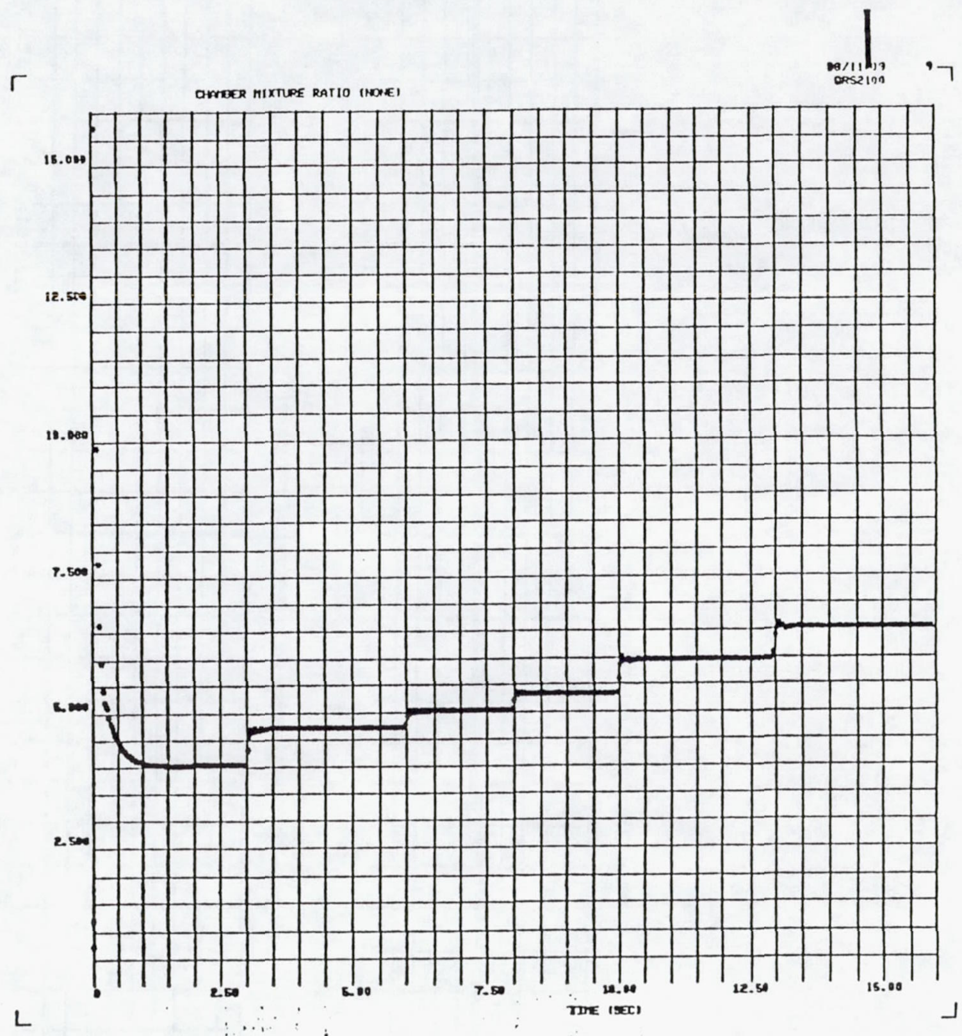
MAIN OXIDIZER TURBINE BYPASS VALVE POSITION (PERCENT)

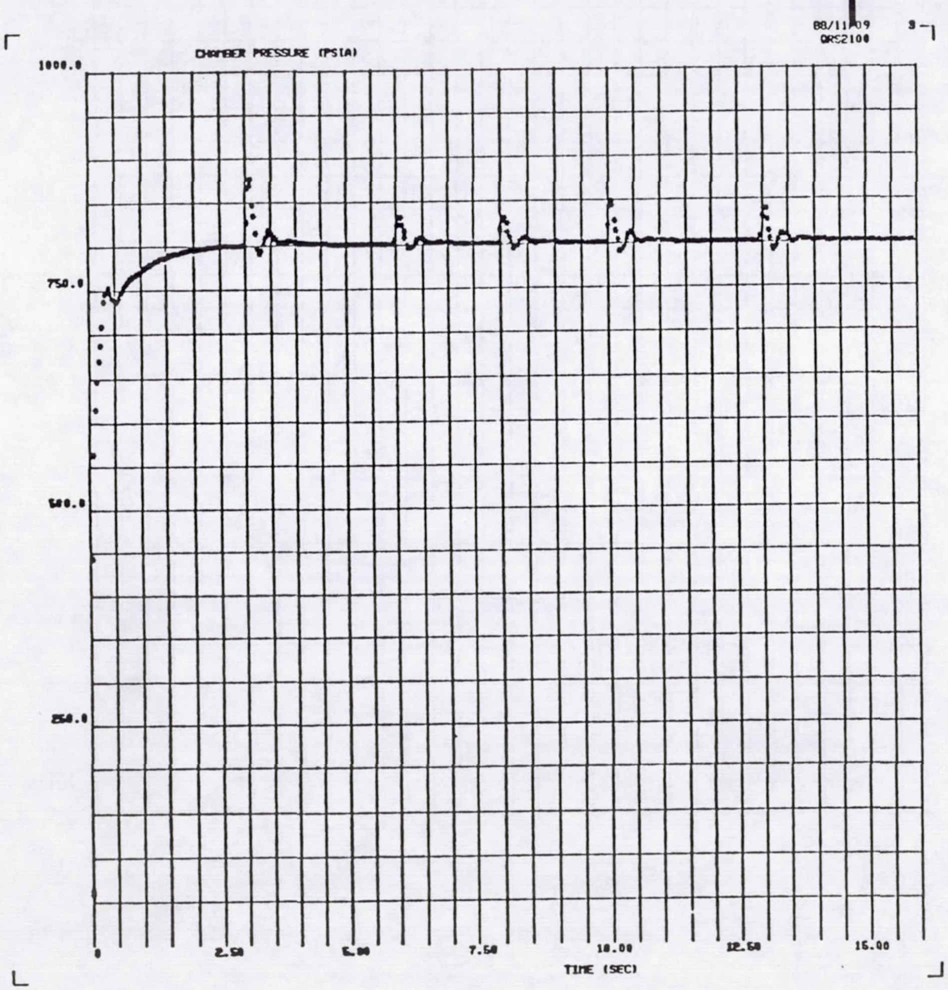


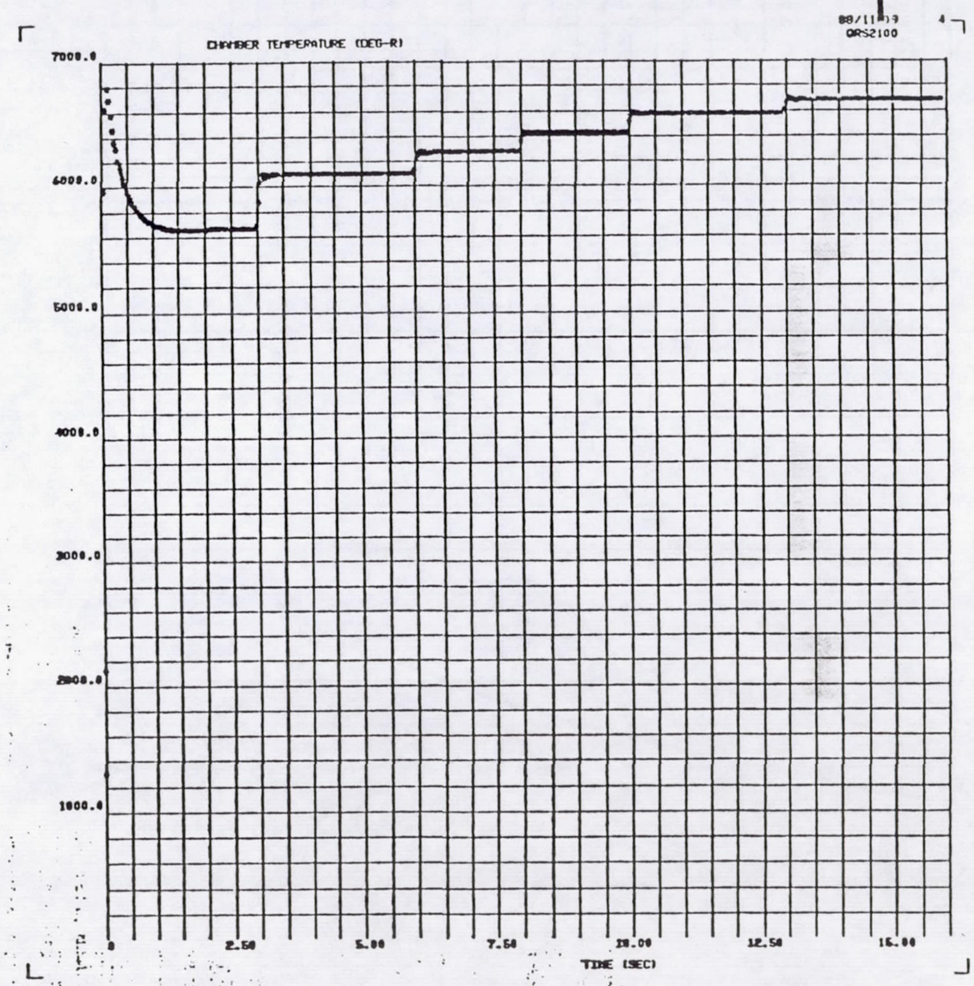
MAIN OXIDIZER VALVE POSITION (PERCENT)




INJECTOR MIXTURE RATIO
88/11/09
QRS2100
30
12.500
10.000
7.500
5.000
2.500
0
2.50
5.00
7.50
10.00
12.50
15.00
TIME (SEC)


CHAMBER MIXTURE RATIO (NONE)
88/11/09
QRS2100
9
15.000
12.500
10.000
7.500
5.000
2.500
0
2.50
5.00
7.50
10.00
12.50
15.00
TIME (SEC)

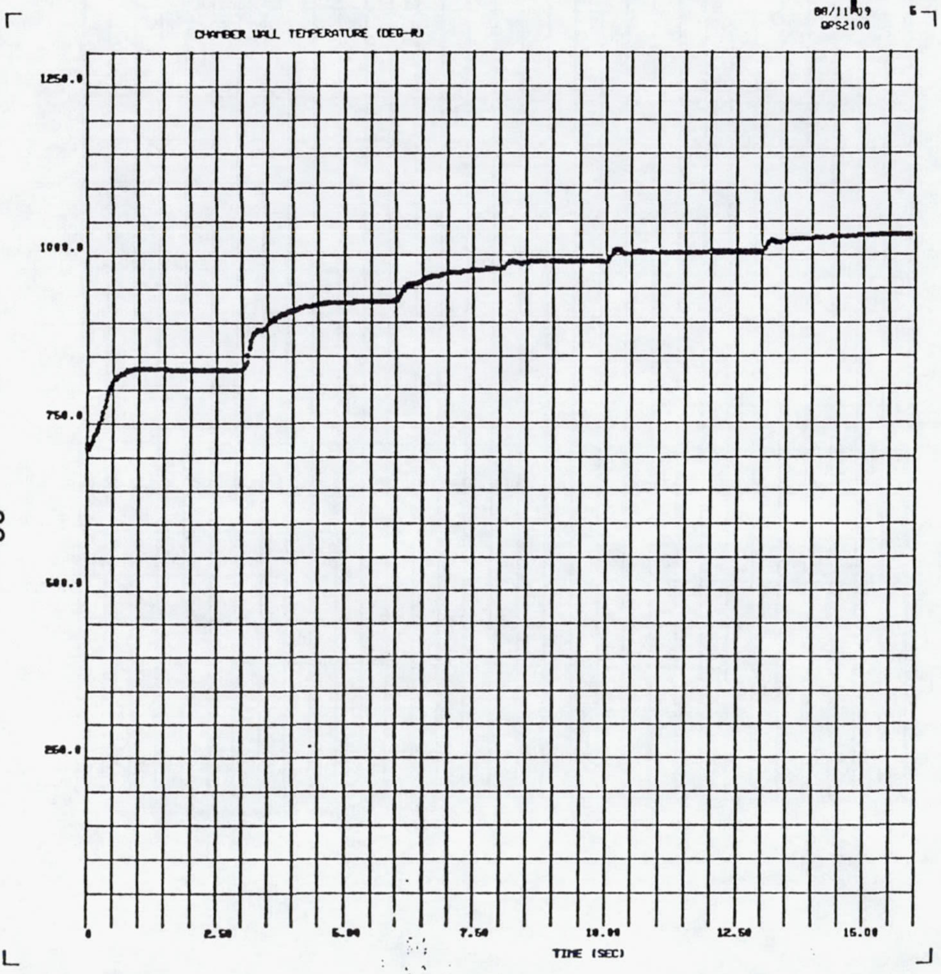

88/11/09
QRS2100
3
CHAMBER PRESSURE (PSIA)
1000.0
750.0
500.0
250.0
0
2.50
5.00
7.50
10.00
12.50
15.00
TIME (SEC)


88/11/09
QRS2100
4
CHAMBER TEMPERATURE (DEG-R)
7000.0
6000.0
5000.0
4000.0
3000.0
2000.0
1000.0
0
2.50
5.00
7.50
10.00
12.50
15.00
TIME (SEC)

091

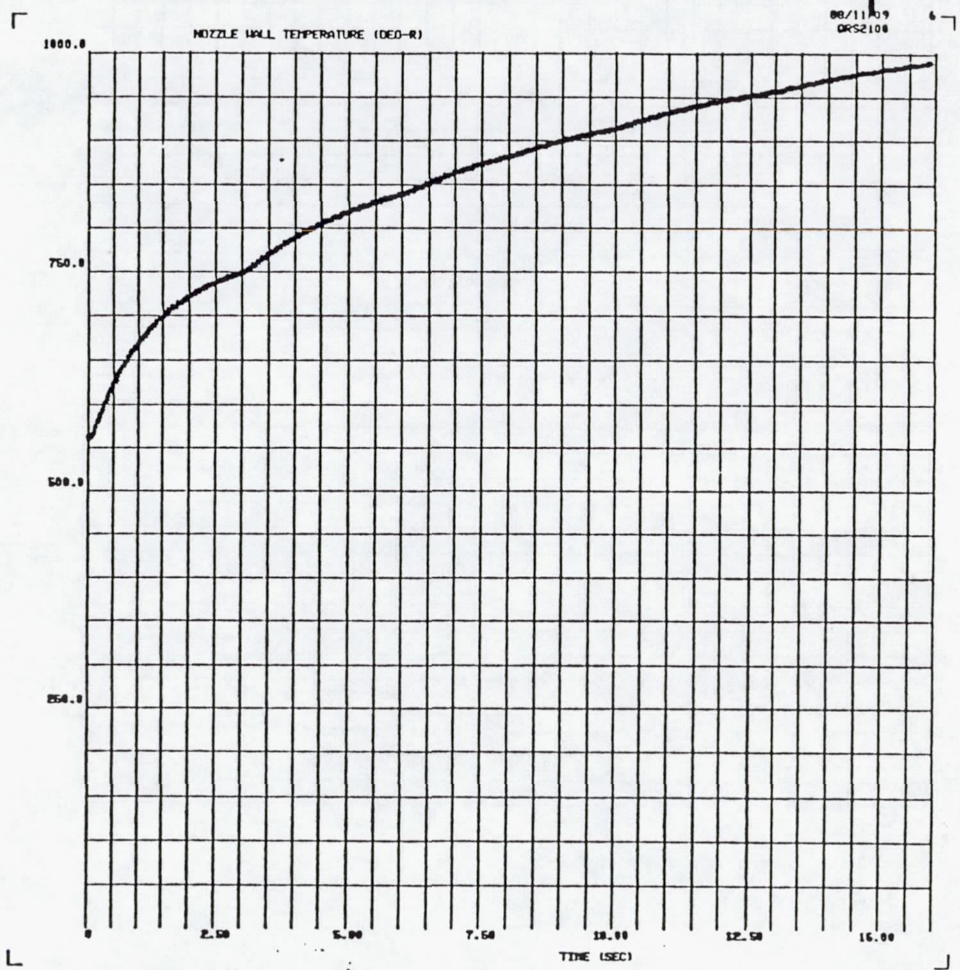
090

A



CHAMBER WALL TEMPERATURE (DEG-R)
08/11/09
QPS2100
5
1250.0
1000.0
750.0
500.0
250.0
0
2.50
5.00
7.50
10.00
12.50
15.00
TIME (SEC)

039



NOZZLE WALL TEMPERATURE (DEG-R)
08/11/09
QPS2100
6
1000.0
750.0
500.0
250.0
0
2.50
5.00
7.50
10.00
12.50
15.00
TIME (SEC)

088

A5

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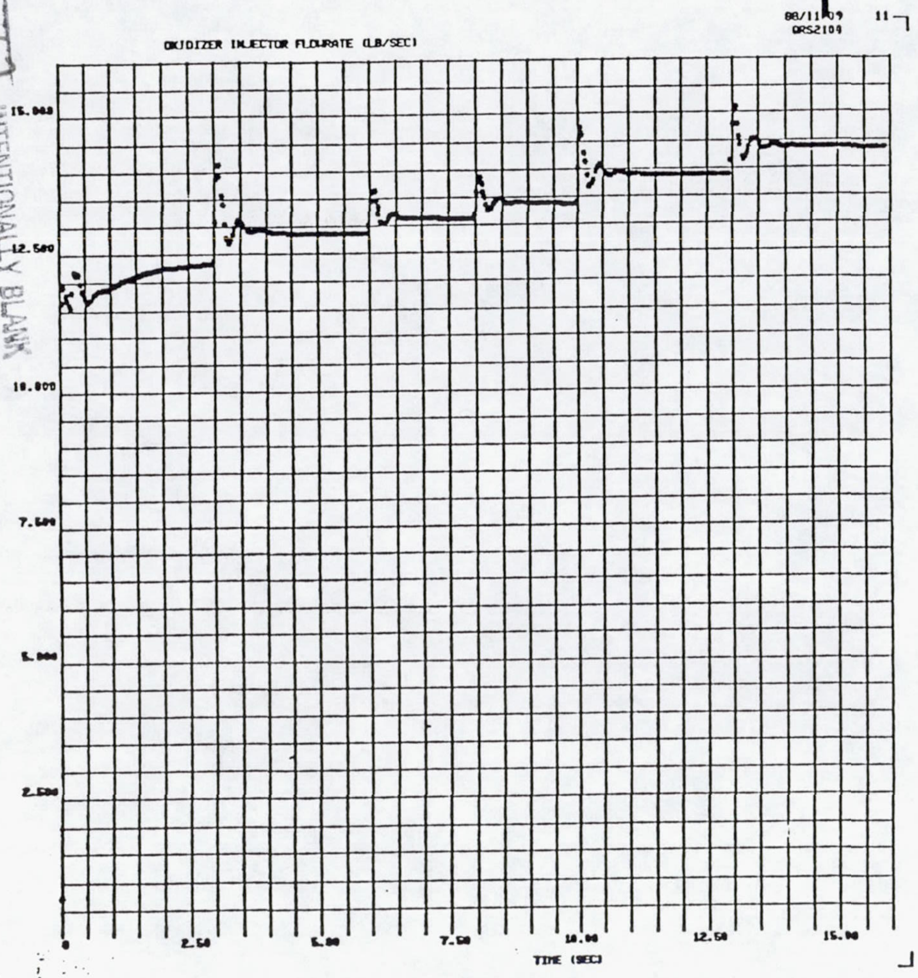

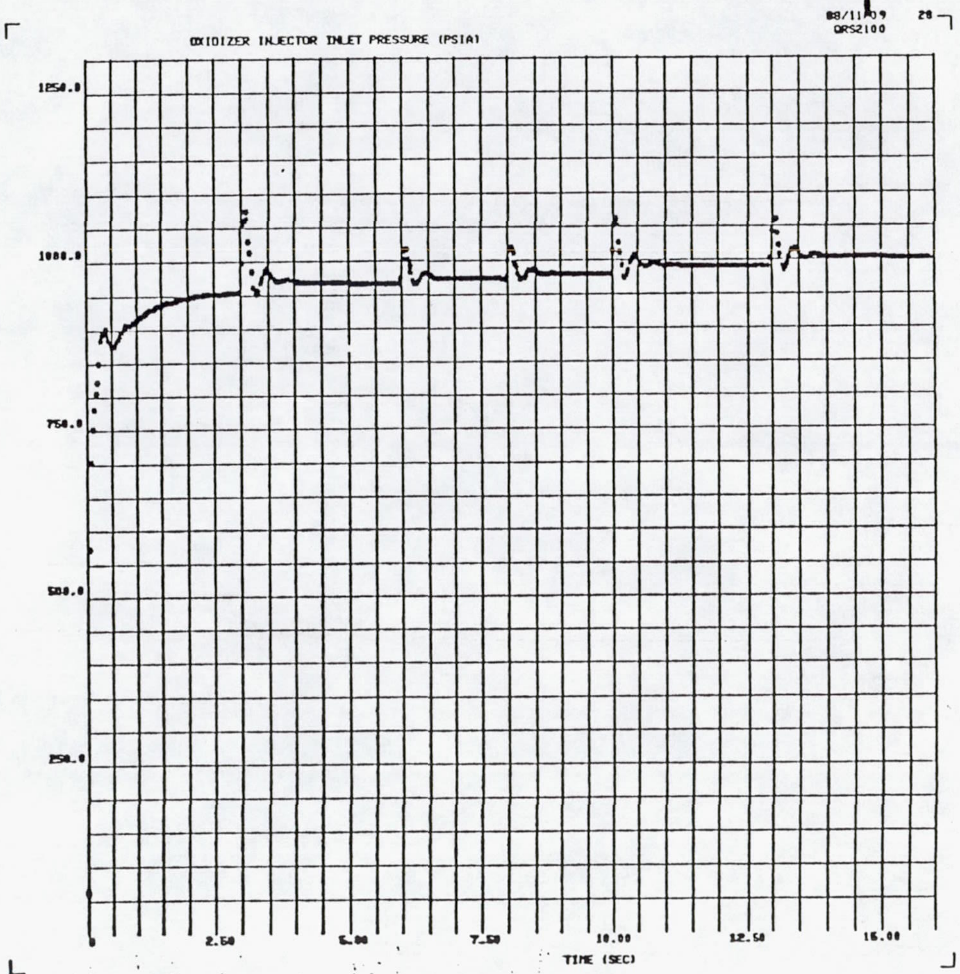

083

066

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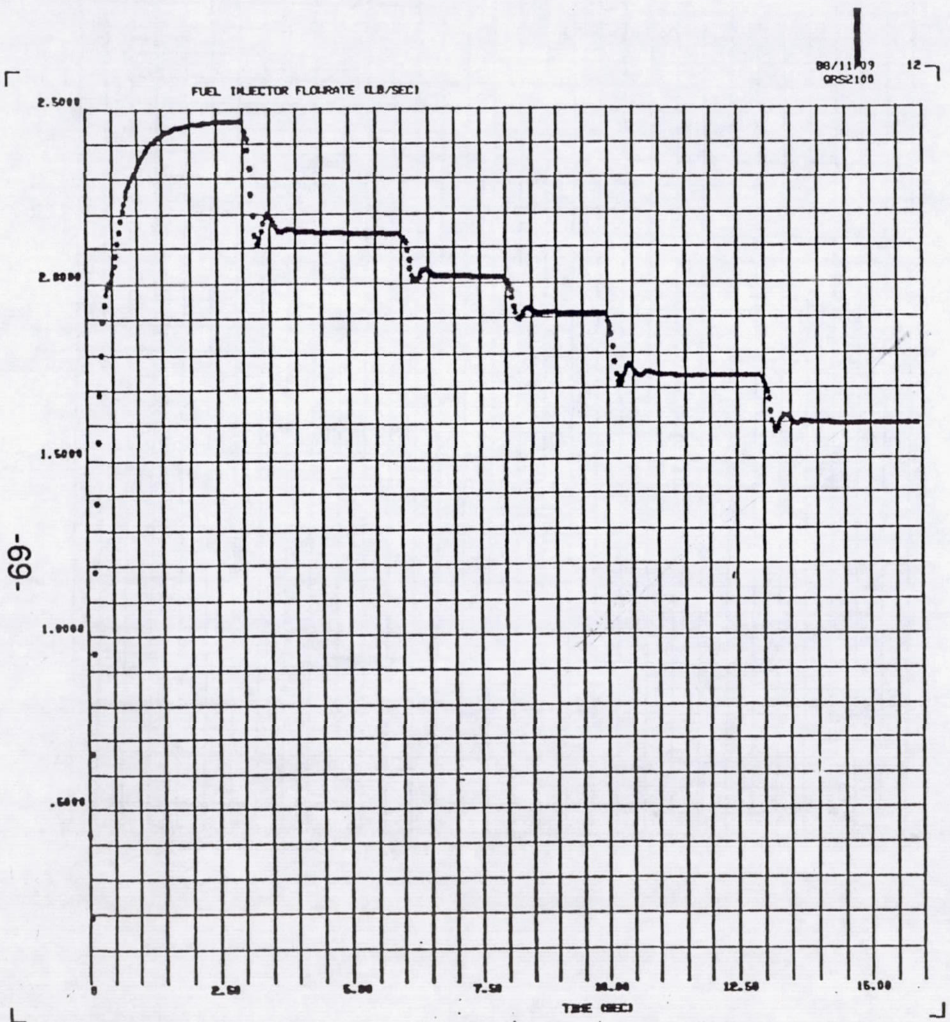
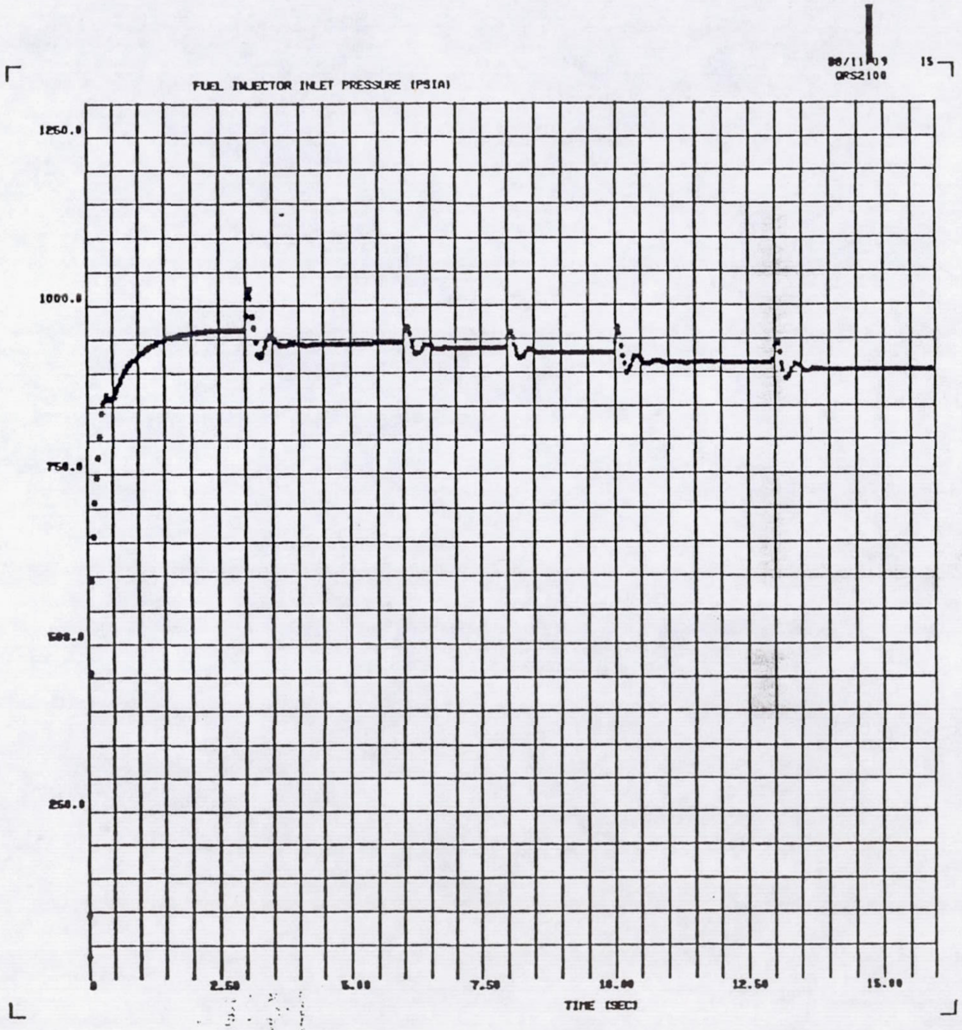
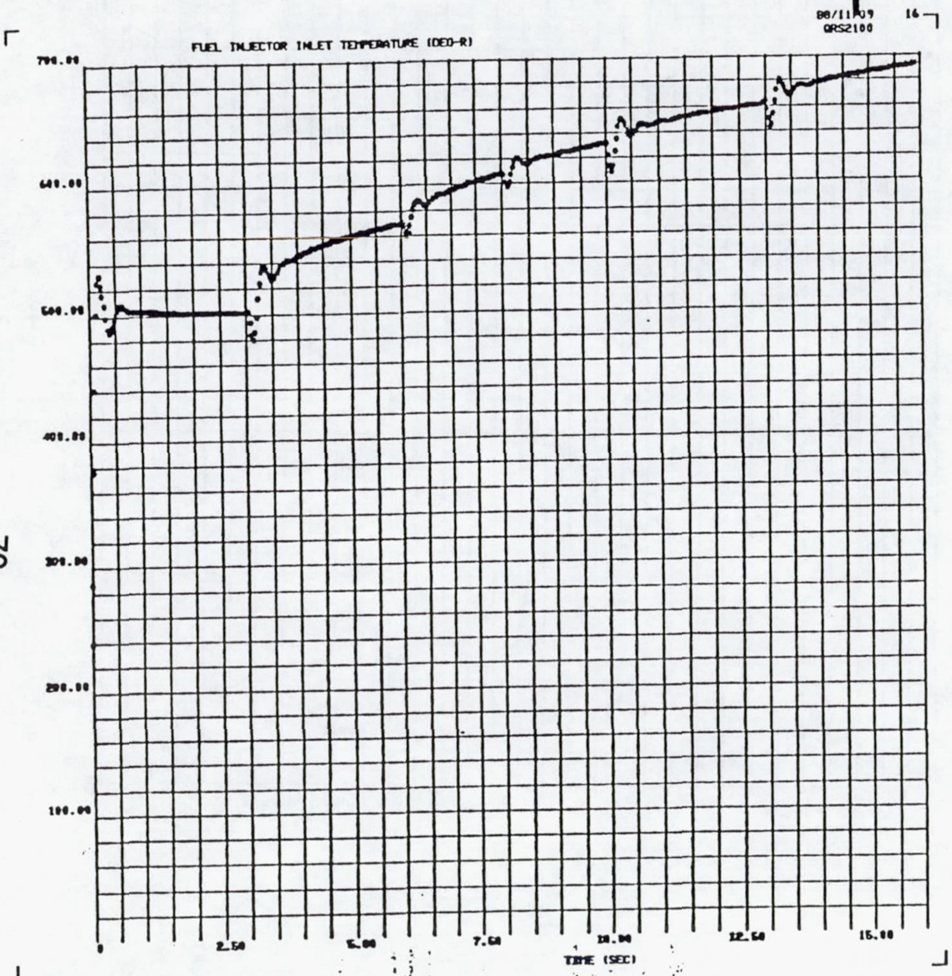
-69-


FUEL INJECTOR FLOWRATE (LB/SEC)
88/11/09
QRS2100
12
2.5000
2.0000
1.5000
1.0000
.5000
0
2.50
5.00
7.50
10.00
12.50
15.00
TIME (SEC)


FUEL INJECTOR INLET PRESSURE (PSIA)
88/11/09
QRS2100
15
1250.0
1000.0
750.0
500.0
250.0
0
2.50
5.00
7.50
10.00
12.50
15.00
TIME (SEC)

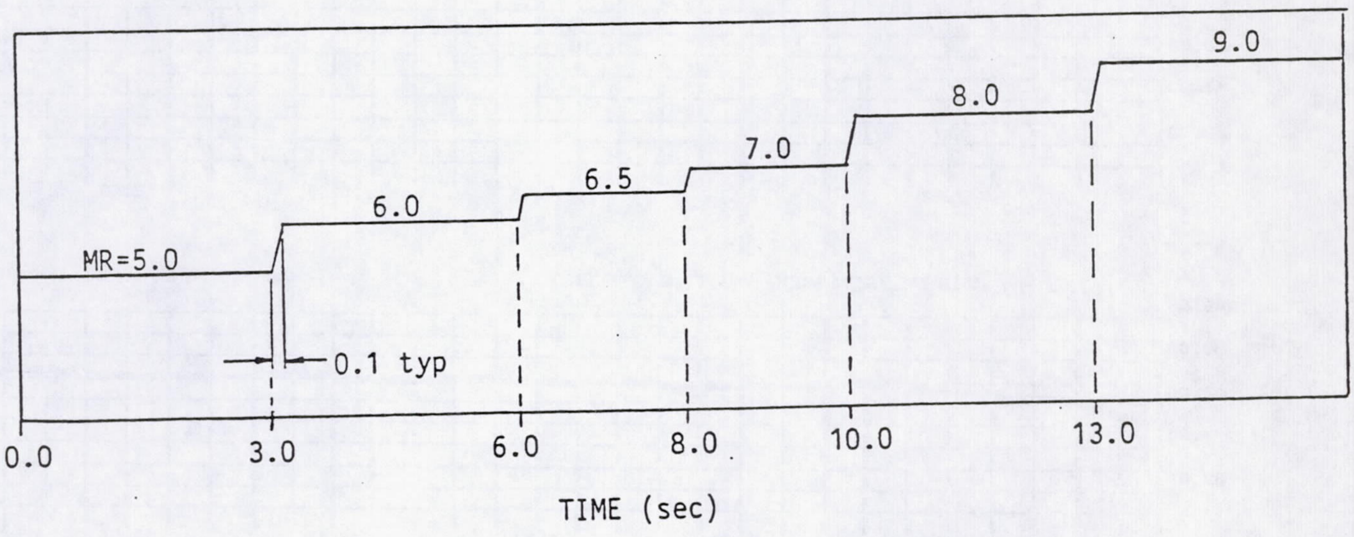
082

079


88/11/09
QRS2100
16
FUEL INJECTOR INLET TEMPERATURE (DEG-R)
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0
2.50
5.00
7.50
10.00
12.50
15.00
TIME (SEC)

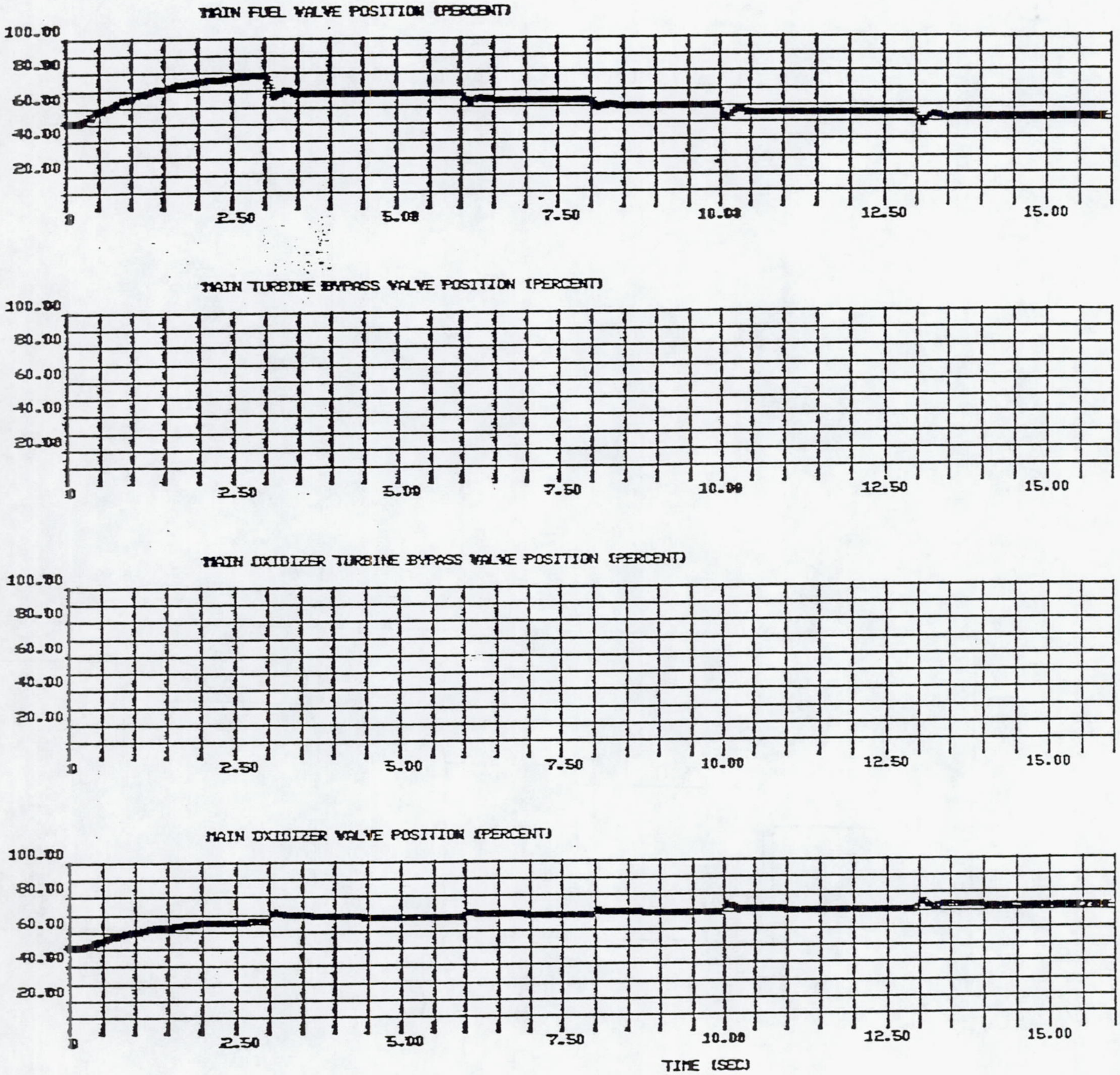
078

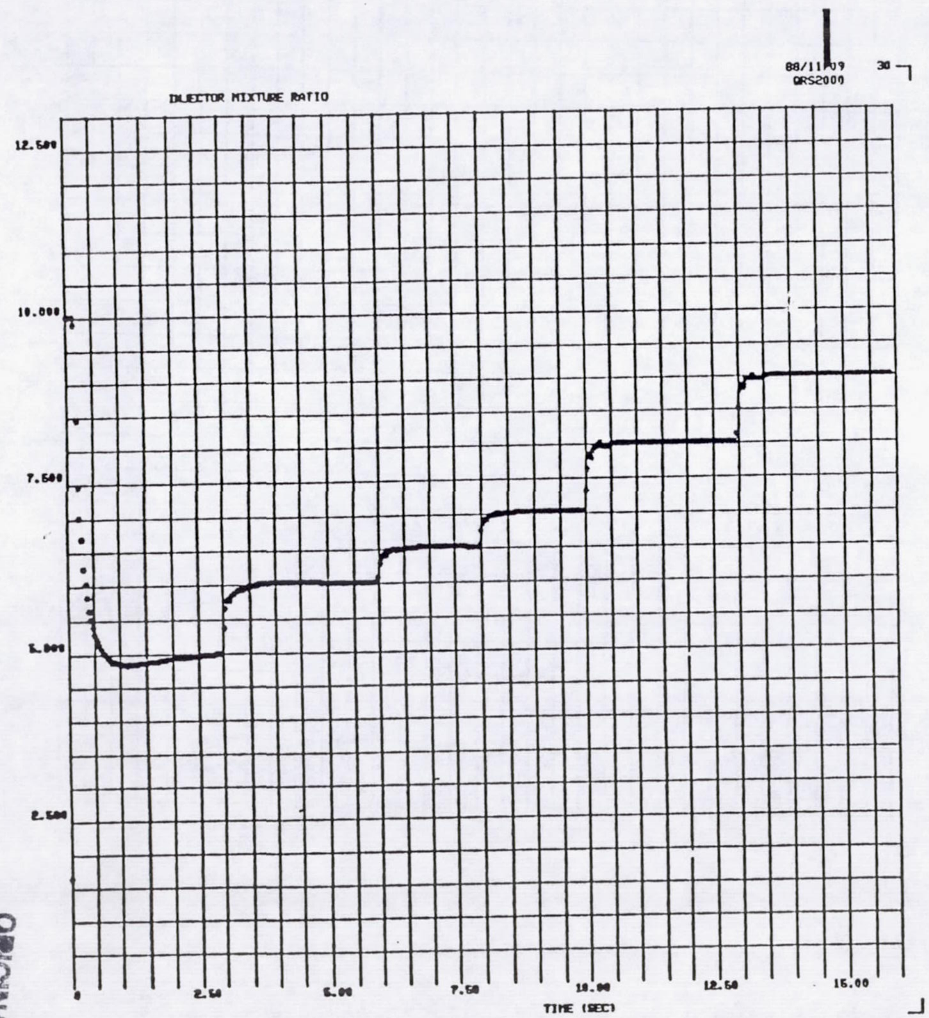
Closed-Loop Mixture Ratio Variations at Pc=1200 psia

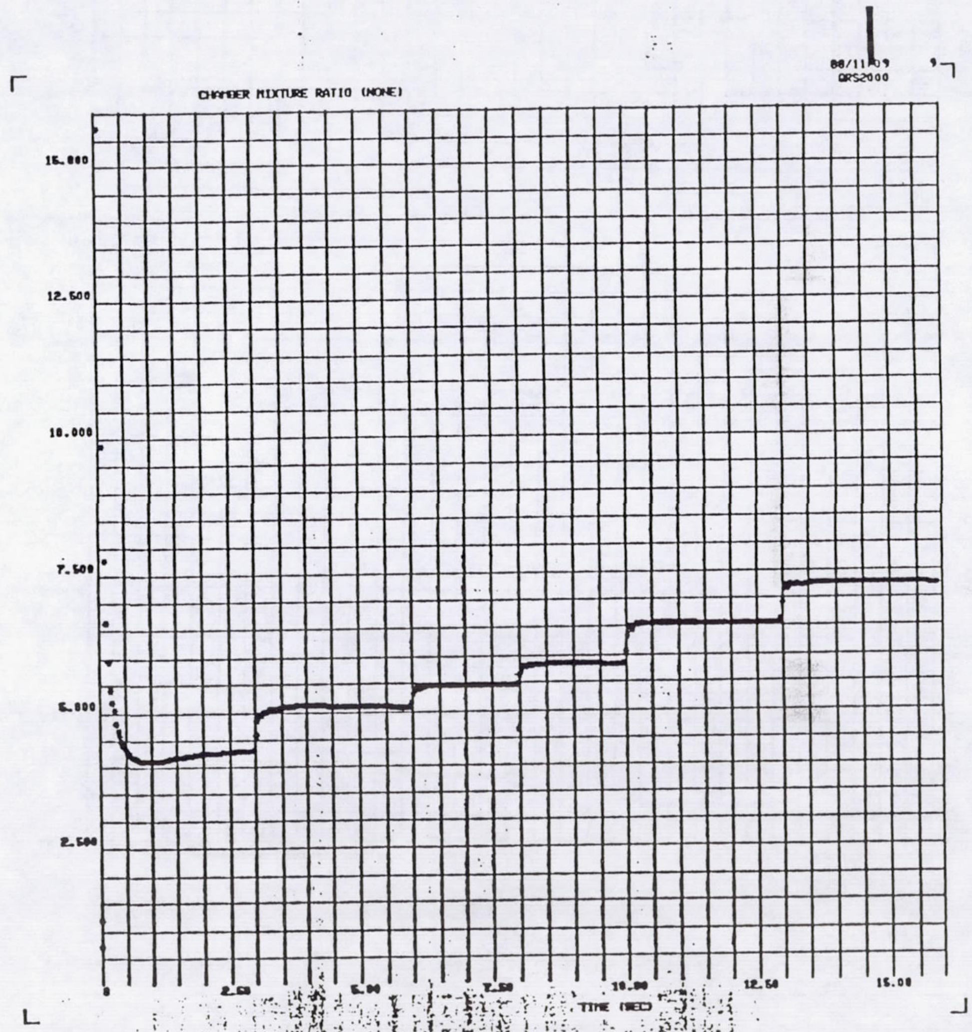


Injector Mixture Ratio Command

B1


MAIN FUEL VALVE POSITION (PERCENT)
100.00
80.00
60.00
40.00
20.00
0
2.50
5.00
7.50
10.00
12.50
15.00
MAIN TURBINE BYPASS VALVE POSITION (PERCENT)
MAIN OXIDIZER TURBINE BYPASS VALVE POSITION (PERCENT)
MAIN OXIDIZER VALVE POSITION (PERCENT)
TIME (SEC)





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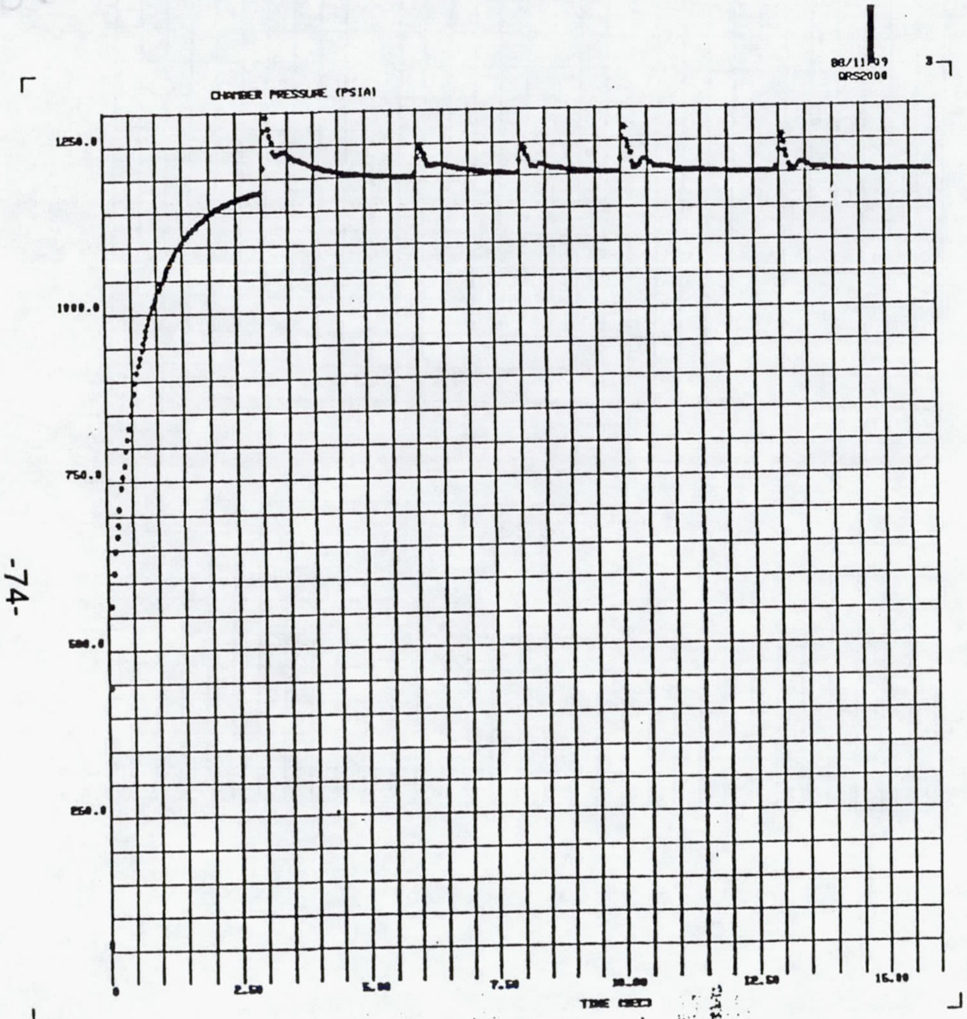
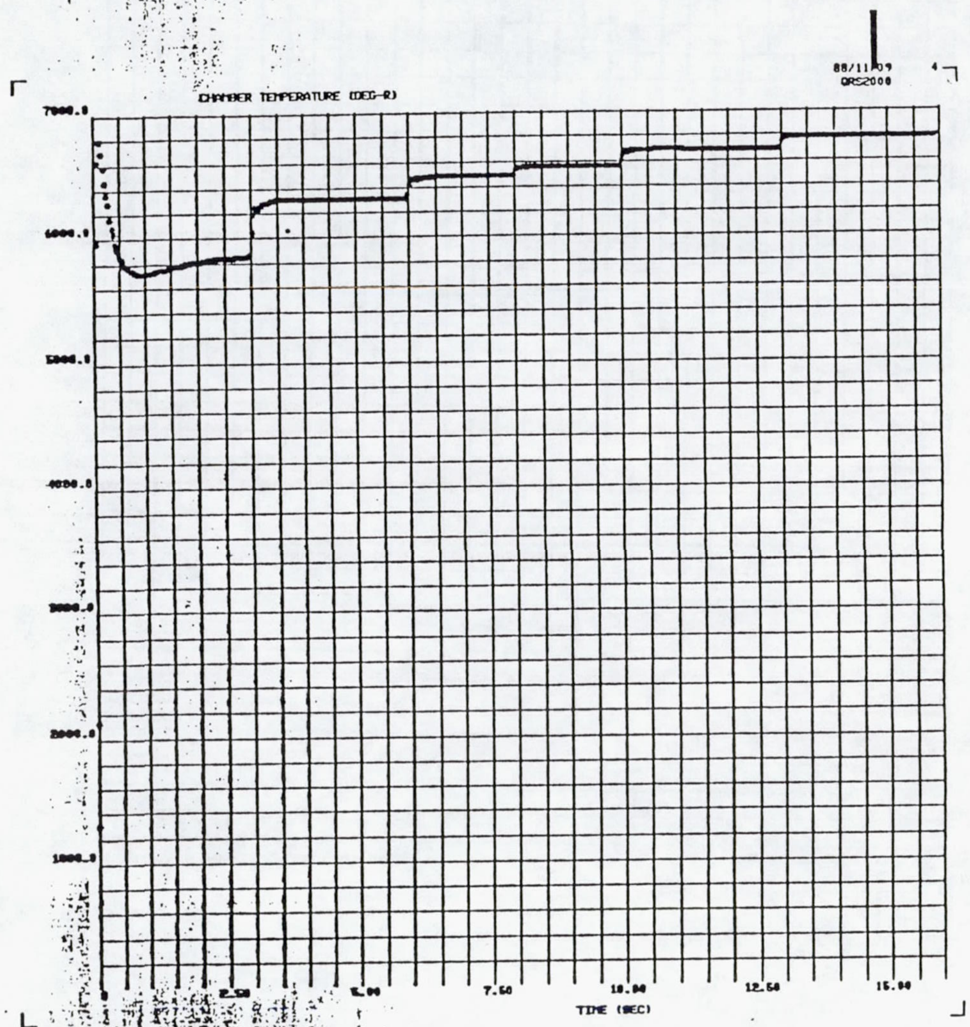
ORIGINAL PAGE IS OF POOR QUALITY

100

121



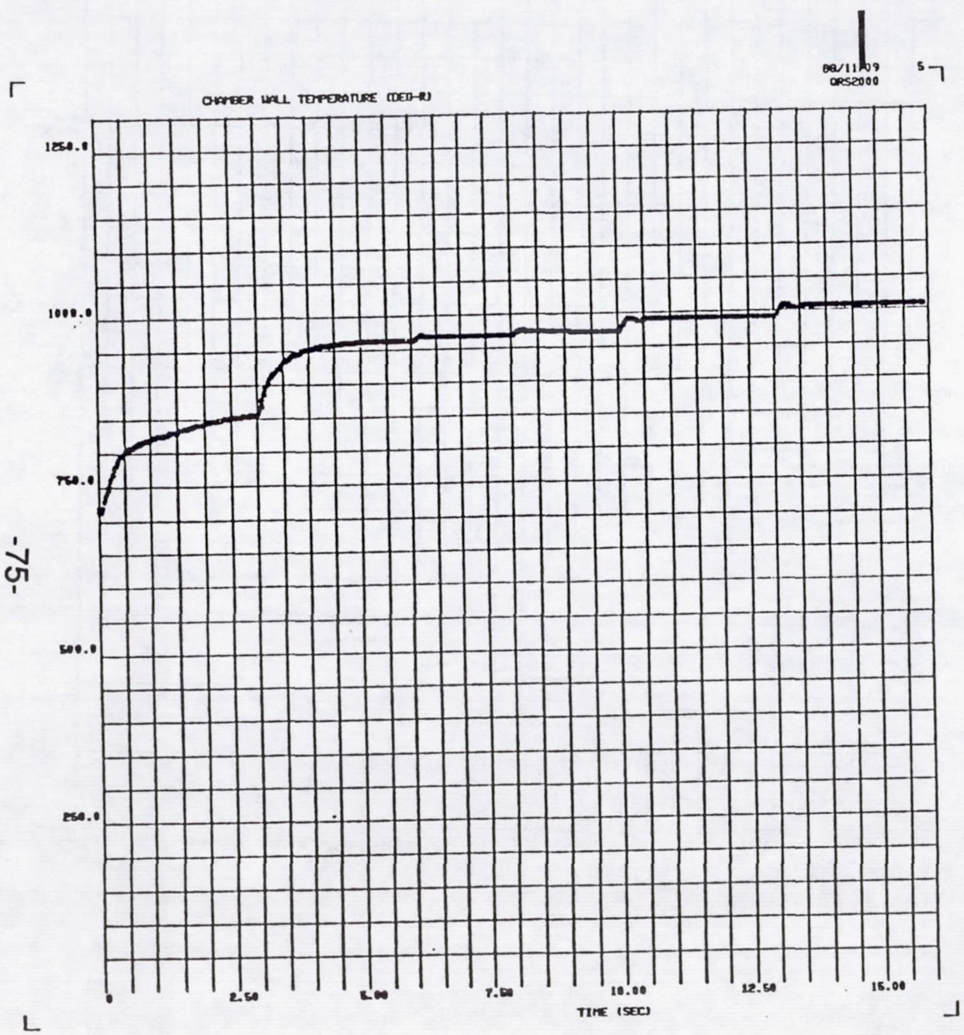
88/11/09
QRS2000
3
CHAMBER PRESSURE (PSIA)
1250.0
1000.0
750.0
500.0
250.0
0
2.50
5.00
7.50
10.00
12.50
15.00
TIME (SEC)

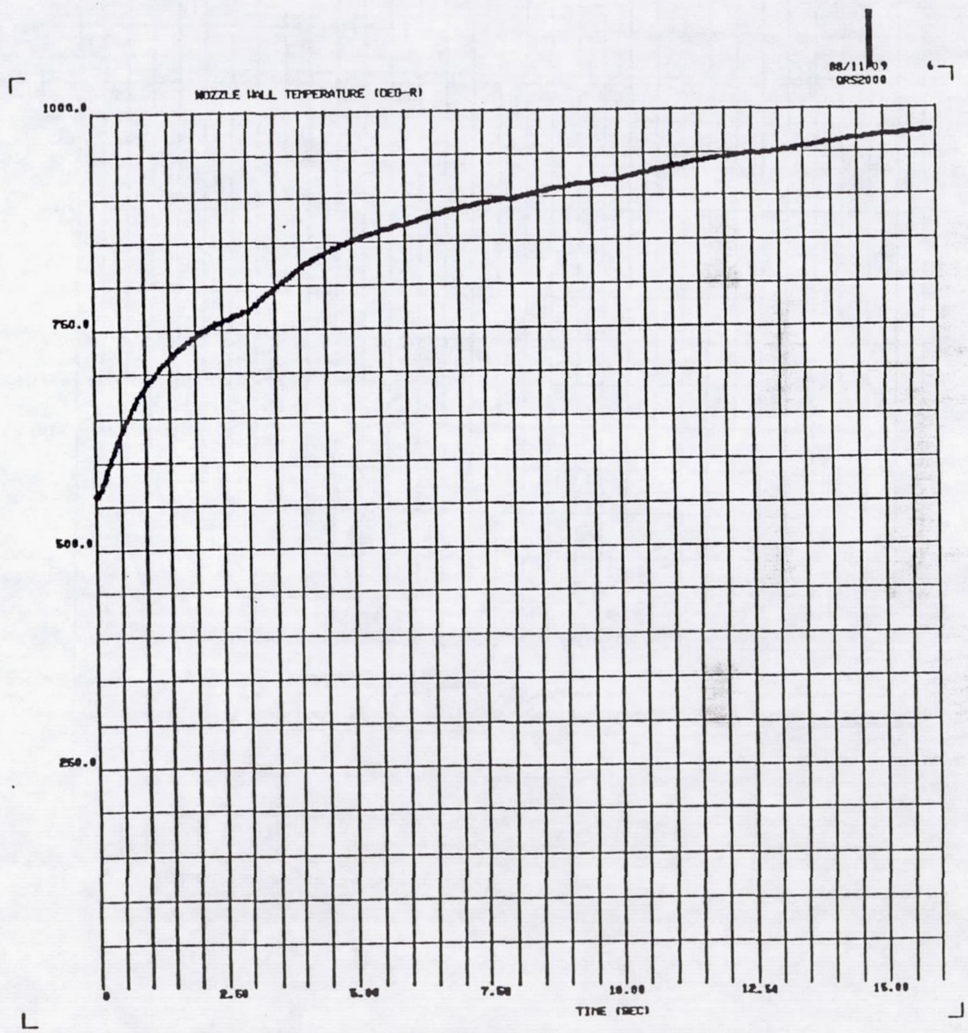


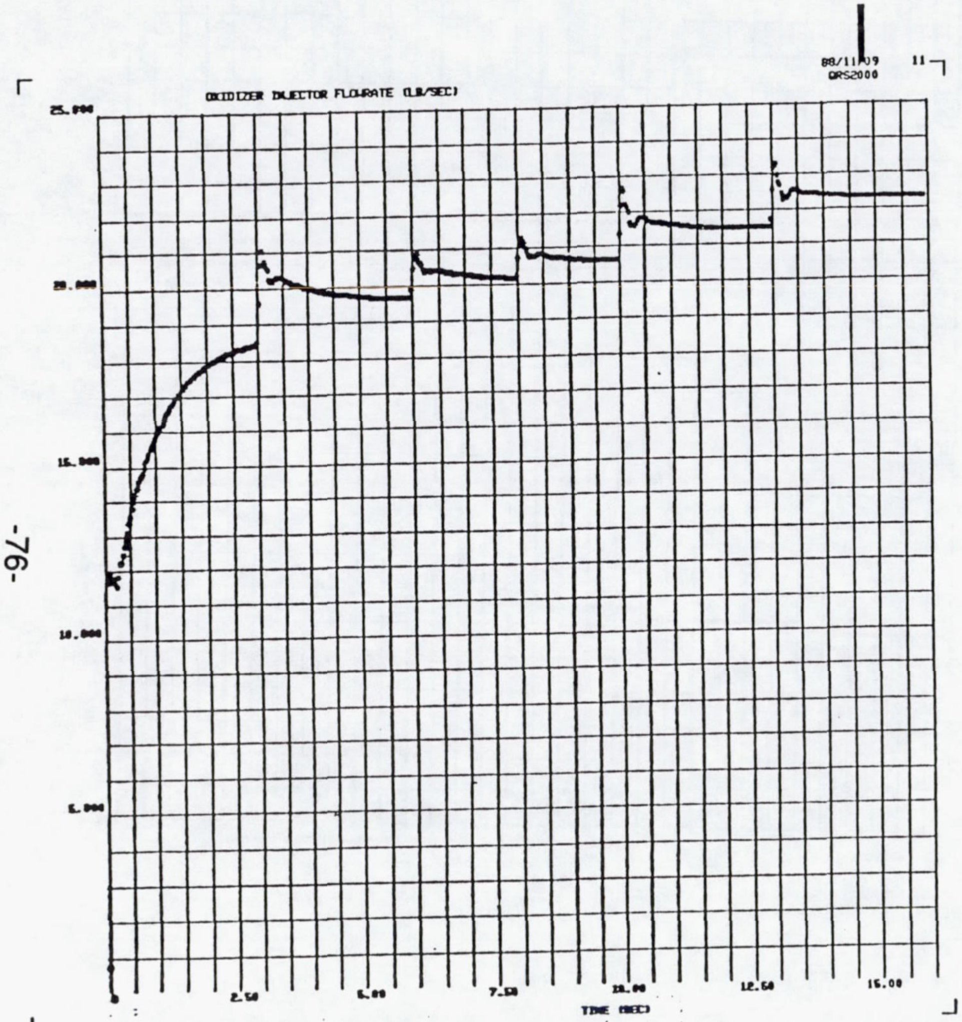
88/11/09
QRS2000
4
CHAMBER TEMPERATURE (DEG-R)
7000.0
6000.0
5000.0
4000.0
3000.0
2000.0
1000.0
0
2.50
5.00
7.50
10.00
12.50
15.00
TIME (SEC)

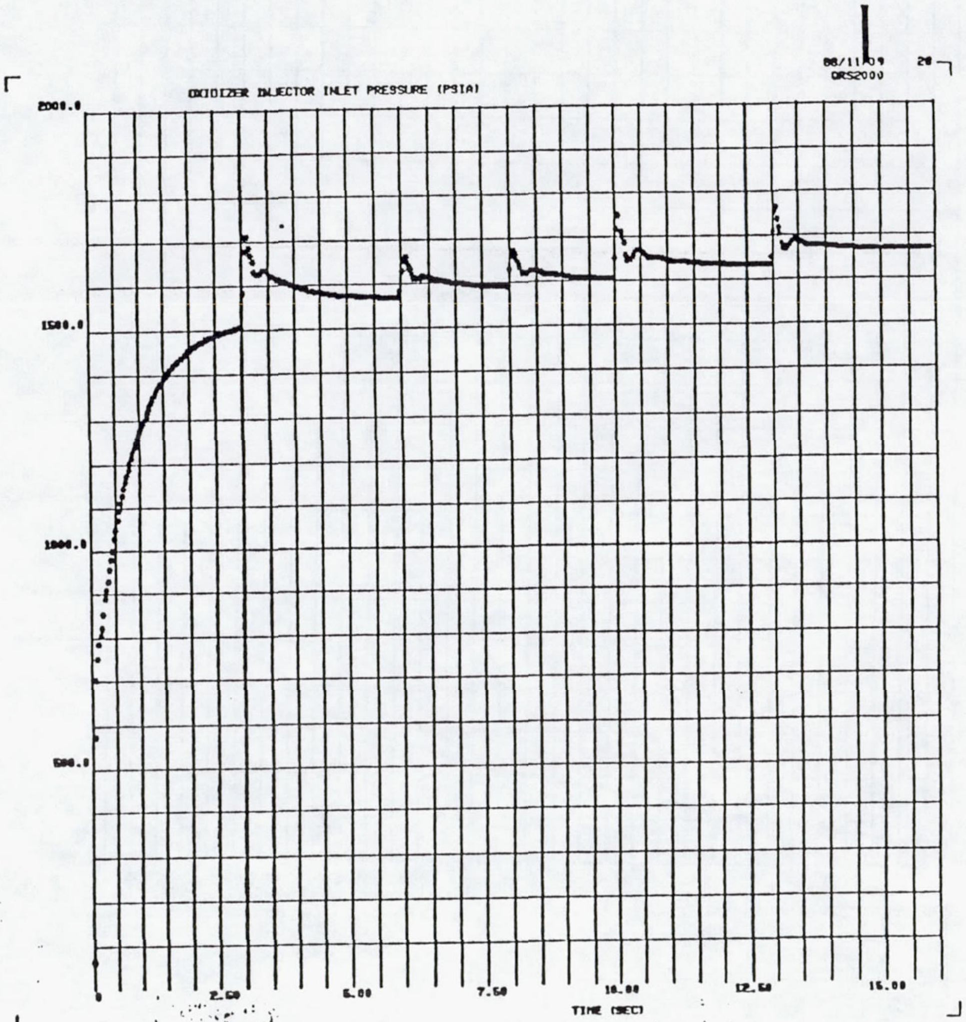
127

126


88/11/09
QRS2000
5
CHAMBER WALL TEMPERATURE (DEG-R)
1250.0
1000.0
750.0
500.0
250.0
0
2.50
5.00
7.50
10.00
12.50
15.00
TIME (SEC)

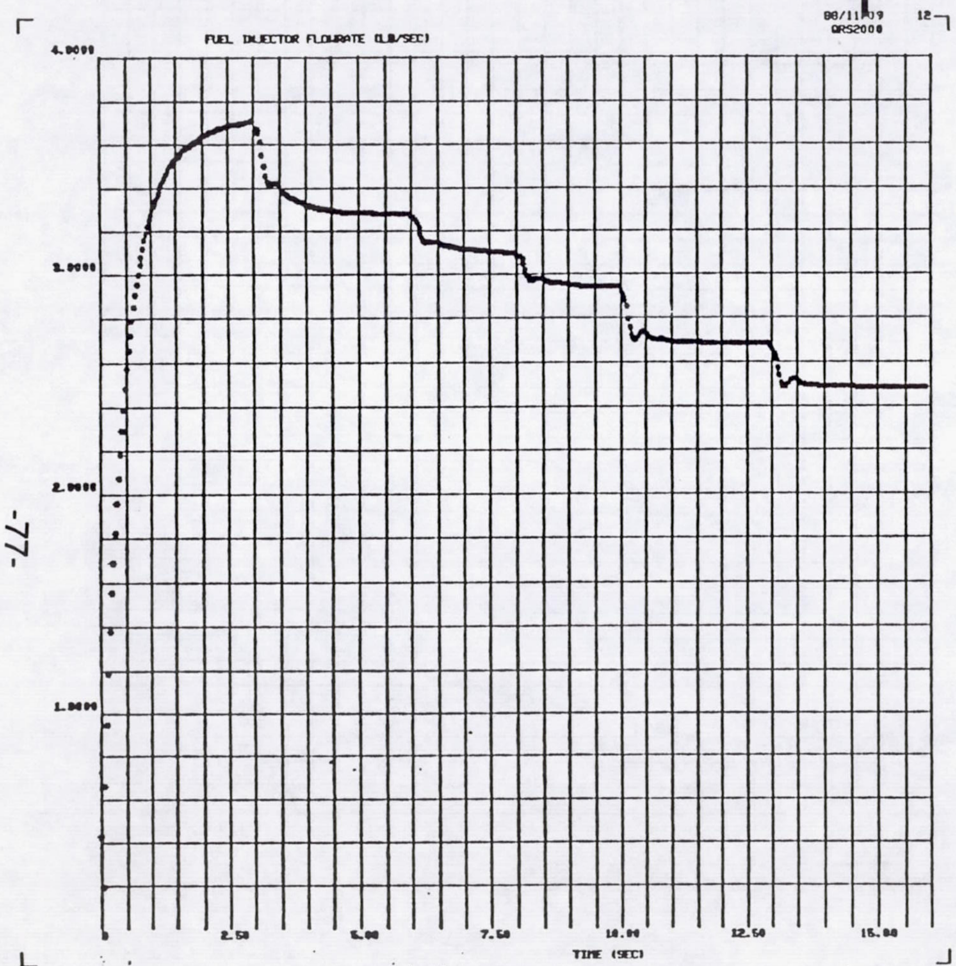

88/11/09
QRS2000
6
NOZZLE WALL TEMPERATURE (DEG-R)
1000.0
750.0
500.0
250.0
0
2.50
5.00
7.50
10.00
12.50
15.00
TIME (SEC)


OXIDIZER INJECTOR FLOWRATE (LB/SEC)
88/11/09
QRS2000
11
25.000
20.000
15.000
10.000
5.000
0
2.50
5.00
7.50
10.00
12.50
15.00
TIME (SEC)


OXIDIZER INJECTOR INLET PRESSURE (PSIA)
88/11/09
QRS2000
20
2000.0
1500.0
1000.0
500.0
0
2.50
5.00
7.50
10.00
12.50
15.00
TIME (SEC)

119

102

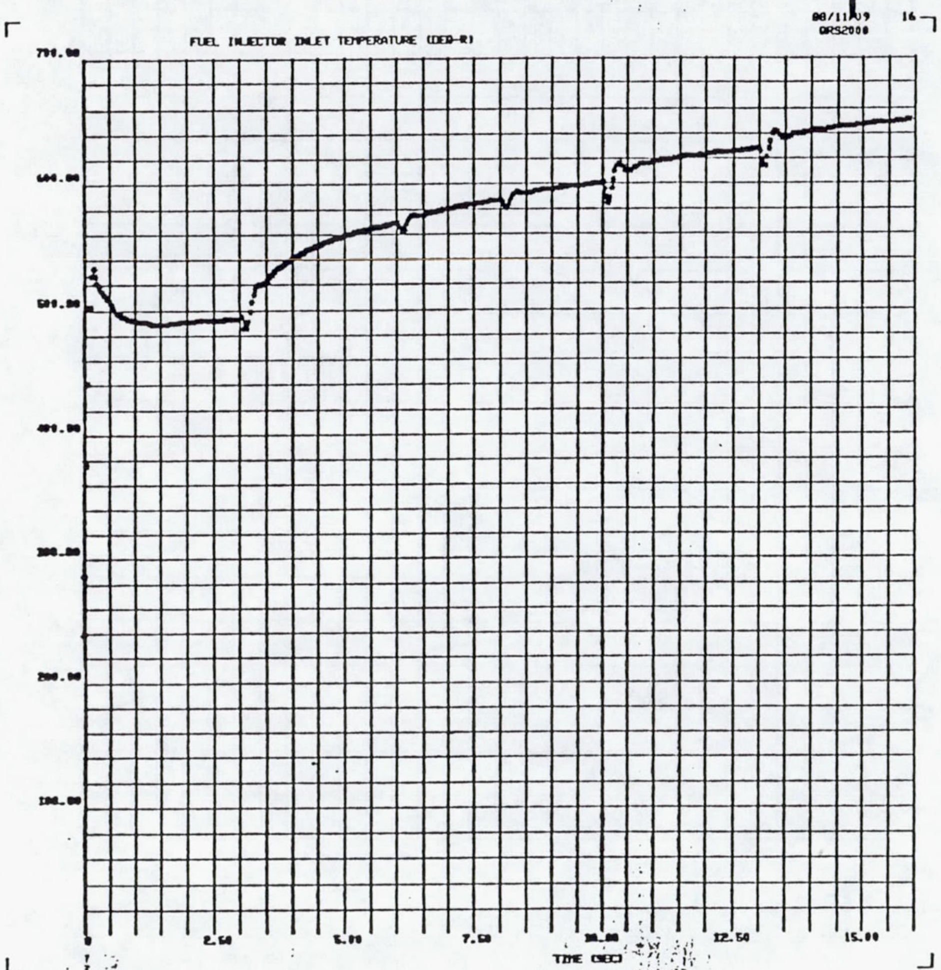


08/11/09 12
QRS2000
FUEL INJECTOR FLOWRATE (LB/SEC)
4.0000
3.0000
2.0000
1.0000
0
2.50
5.00
7.50
10.00
12.50
15.00
TIME (SEC)

118

08/11/09 15
QRS2000
FUEL INJECTOR INLET PRESSURE (PSIA)
1500.0
1250.0
1000.0
750.0
500.0
250.0
0
2.50
5.00
7.50
10.00
12.50
15.00
TIME (SEC)

115


FUEL INJECTOR INLET TEMPERATURE (DEG-R)
08/11/09
QRS2000
16
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0
2.50
5.00
7.50
10.00
12.50
15.00
TIME (SEC)

114

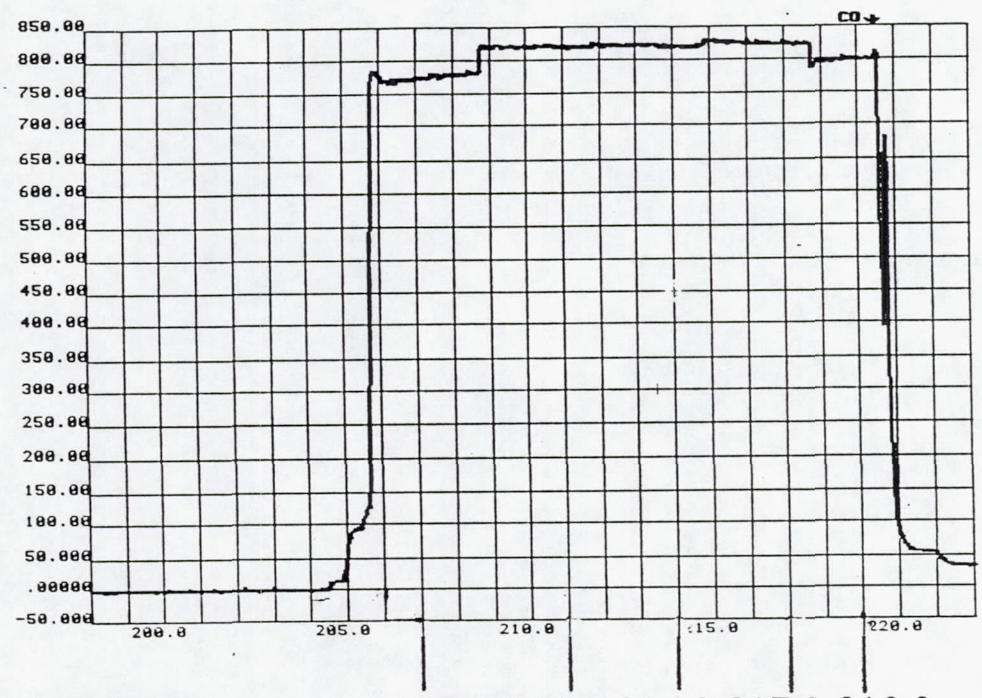
B8

APPENDIX III

III. Sample Reduced Data From 0.040 in. Rib & Smooth Wall Tests

Test 017 - 016: 0.040 in. Ribbed Combustor
Reduced Data Time Slices

Pc
(psia)



Time Slice:	207.0	211.0	214.0	217.0	219.0
SEC					
MR (PREDICTED)	5.0	6.0	6.5	7.0	5.0
MR (ACTUAL)	4.3	4.9	5.3	5.8	4.7

T= 207.0, MR:5.0 (VS 4.3 ACTUAL)

LH2 PRESS. UPSTREAM OF THE MAIN FUEL VALVE 3454.8300000 PSIG
LH2 PRESS. DOWNSTREAM OF THE MAIN FUEL VALVE 1578.4100000 PSIG
LH2 PRESS. INLET TO THE THRUST CHAMBER COOLANT JACKET 1676.4800000 PSIG
H2 PRESS. EXHAUST FROM THE THRUST CHAMBER COOLING JACKET 1444.8900000 PSIG
H2 PRESS. INLET TO THE NOZZLE COOLING JACKET 1427.6300000 PSIG
H2 PRESS. EXHAUST FROM THE NOZZLE COOLING JACKET 1376.5900000 PSIG
H2 PRESS. EXHAUST FROM THE NOZZLE COOLING JACKET-REDUNDANT 1376.5900000PSIG
NO PRESSURE AT P8
H2 PRESS. INLET TO THE FUEL MANIFOLD 916.3100000 PSIG
GH2 PRESS. INLET TO THE OLD FUEL MANIFOLD 1589.3800000 PSIG
CALORIMETER CHANNEL 11 EXHAUST PRESSURE 1575.5700000 PSIG
CALORIMETER CHANNEL 12 EXHAUST PRESSURE 1496.0200000 PSIG
CALORIMETER CHANNEL 13 EXHAUST PRESSURE 1452.8500000 PSIG
CALORIMETER CHANNEL 14 EXHAUST PRESSURE 1512.7000000 PSIG
CALORIMETER CHANNEL 15 EXHAUST PRESSURE 1530.8300000 PSIG
CALORIMETER CHANNEL 16 EXHAUST PRESSURE 1415.8600000 PSIG
CALORIMETER CHANNEL 17 EXHAUST PRESSURE 1483.9600000 PSIG
CALORIMETER CHANNEL 18 EXHAUST PRESSURE 1533.4600000 PSIG
CALORIMETER CHANNEL 19 EXHAUST PRESSURE 1436.3200000 PSIG
CALORIMETER CHANNEL 20 EXHAUST PRESSURE 1422.9200000 PSIG
CALORIMETER CHANNEL 21 EXHAUST PRESSURE 1485.0200000 PSIG
LOX PRESS. INLET TO THE MAIN OXIDIZER VALVE 2707.2300000 PSIG
LOX PRESS. EXHAUST FROM THE MAIN OXIDIZER VALVE 845.2300000 PSIG
H2O PRESS. CALORIMETER INLET MANIFOLD 3491.0200000 PSIG
GOX PRESS. INLET TO THE IGNITER VENTURI 2260.3500000 PSIG
NO PRESSURE AT P26
GH2 PRESS. INLET TO THE IGNITER VENTURI 2020.3500000 PSIG
NO PRESSURE AT P28
LOX DOME HIGH FREQUENCY PRESSURE TRANSDUCER 2560.0000000 PSIG
CHAMBER PRESSURE 774.4100000 PSIG
CHAMBER PRESSURE 779.6400000 PSIG
IGNITER PRESSURE 809.6400000 PSIG
IGNITER PRESSURE 806.4000000 PSIG
GOX PRESS. EXHAUST FROM THE IGNITER VENTURI 823.7400000 PSIG
GH2 PRESS. EXHAUST FROM THE IGNITER VENTURI 912.6800000 PSIG
H2O PRESS. CALORIMETER EXHAUST PLENUM 756.7500000 PSIG
CALORIMETER CHANNEL 1 INLET PRESSURE 2859.3600000 PSIG
CALORIMETER CHANNEL 2 INLET PRESSURE 2846.7200000 PSIG
CALORIMETER CHANNEL 3 INLET PRESSURE 2743.5100000 PSIG
CALORIMETER CHANNEL 4 INLET PRESSURE 2887.4200000 PSIG
CALORIMETER CHANNEL 5 INLET PRESSURE 2935.5100000 PSIG
CALORIMETER CHANNEL 6 INLET PRESSURE 2729.6800000 PSIG
CALORIMETER CHANNEL 7 INLET PRESSURE 2773.3300000 PSIG
CALORIMETER CHANNEL 8 INLET PRESSURE 2809.1800000 PSIG
CALORIMETER CHANNEL 9 INLET PRESSURE 2775.3200000 PSIG
CALORIMETER CHANNEL 10 INLET PRESSURE 2709.4700000 PSIG
CALORIMETER CHANNEL 11 INLET PRESSURE 2835.5000000 PSIG

LH2 TEMP. UPSTREAM OF THE MAIN FUEL VALVE -389.0000000 DEG F
LH2 TEMP. DOWNSTREAM OF THE MAIN FUEL VALVE -389.0000000 DEG F
LH2 TEMP. INLET TO THE THRUST CHAMBER COOLING JACKET -367.7500000 DEG F
H2 TEMP. EXHAUST FROM THE THRUST CHAMBER COOLING JACKET -12.8900000 DEG F
H2 TEMP. INLET TO THE NOZZLE COOLING JACKET -12.0800000 DEG F
H2 TEMP. EXHAUST FROM THE NOZZLE COOLING JACKET -119.4700000 DEG F
LOX TEMP. INLET TO THE MAIN OXIDIZER VALVE -268.5900000 DEG F
LOX TEMP. EXHAUST FROM THE MAIN OXIDIZER VALVE -268.5900000 DEG F
H2 TEMP. INLET TO THE FUEL MANIFOLD 19.8600000 DEG F
GH2 TEMP. INLET TO THE OLD FUEL MANIFOLD 61.9400000 DEG F
CALORIMETER CHANNEL 11 EXHAUST TEMP. 150.7800000 DEG F
CALORIMETER CHANNEL 12 EXHAUST TEMP. 147.0500000 DEG F

CALORIMETER CHANNEL 13 EXHAUST TEMP. 152.0200000 DEG F
CALORIMETER CHANNEL 14 EXHAUST TEMP. 153.6200000 DEG F
CALORIMETER CHANNEL 15 EXHAUST TEMP. 155.2500000 DEG F
CALORIMETER CHANNEL 16 EXHAUST TEMP. 159.9900000 DEG F
CALORIMETER CHANNEL 17 EXHAUST TEMP. 162.2400000 DEG F
CALORIMETER CHANNEL 18 EXHAUST TEMP. 163.0800000 DEG F
CALORIMETER CHANNEL 19 EXHAUST TEMP. 156.3800000 DEG F
CALORIMETER CHANNEL 20 EXHAUST TEMP. 152.3400000 DEG F
CALORIMETER CHANNEL 21 EXHAUST TEMP. 166.6100000 DEG F
GOX TEMP. INLET TO THE IGNITER VENTURI 44.4500000 DEG F
GH2 TEMP. INLET TO THE IGNITER VENTURI 55.5900000 DEG F
H2O TEMP. CALORIMETER INLET MANIFOLD 68.0000000 DE G F
TEMP. MAIN OXIDIZER VALVE OPERATOR 32.1200000 DEG F
TEMP. MAIN FUEL VALVE OPERATOR 84.8600000 DEG F
H2O TEMP. CALORIMETER EXHAUST PLENUM 93.3600000 DE G F

LOX PRESS. UPSTREAM OF SYSTEM VENTURI 2736.5100000 P SIG
LOX PRESS. DOWNSTREAM OF SYSTEM VENTURI 2707.6500000 PSIG
LH2 PRESS. UPSTREAM OF SYSTEM VENTURI 3455.8600000 P SIG
LH2 PRESS. DOWNSTREAM OF SYSTEM VENTURI 3421.8700000 PSIG

LOX TEMP. UPSTREAM OF THE SYSTEM VENTURI -272.8900000 DEG F
LH2 TEMP. UPSTREAM OF THE SYSTEM VENTURI -382.3100000 DEG F

THE NOZZLE MIXTURE RATIO IS 3.5265090

THE INJECTOR MIXTURE RATIO IS 4.3160000

CORRECTED CALORIMETER CHANNEL 1 INLET PRESS. 2839.1600000 PSIG
CORRECTED CALORIMETER CHANNEL 2 INLET PRESS. 2835.3200000 PSIG
CORRECTED CALORIMETER CHANNEL 3 INLET PRESS. 2726.1100000 PSIG
CORRECTED CALORIMETER CHANNEL 4 INLET PRESS. 2869.2200000 PSIG
CORRECTED CALORIMETER CHANNEL 5 INLET PRESS. 2924.6100000 PSIG
CORRECTED CALORIMETER CHANNEL 6 INLET PRESS. 2723.0800000 PSIG
CORRECTED CALORIMETER CHANNEL 7 INLET PRESS. 2762.5300000 PSIG
CORRECTED CALORIMETER CHANNEL 8 INLET PRESS. 2796.9800000 PSIG
CORRECTED CALORIMETER CHANNEL 9 INLET PRESS. 2761.4200000 PSIG
CORRECTED CALORIMETER CHANNEL 10 INLET PRESS. 2696.6700000 PSIG
CORRECTED CALORIMETER CHANNEL 11 INLET PRESS. 2818.7000000 PSIG

CALORIMETER CHANNEL 1 EXHAUST SATURATION PRESS. 3.7940980 PSIA
CALORIMETER CHANNEL 2 EXHAUST SATURATION PRESS. 3.4582200 PSIA
CALORIMETER CHANNEL 3 EXHAUST SATURATION PRESS. 3.9117060 PSIA
CALORIMETER CHANNEL 4 EXHAUST SATURATION PRESS. 4.0680180 PSIA
CALORIMETER CHANNEL 5 EXHAUST SATURATION PRESS. 4.2326650 PSIA
CALORIMETER CHANNEL 6 EXHAUST SATURATION PRESS. 4.7438530 PSIA
CALORIMETER CHANNEL 7 EXHAUST SATURATION PRESS. 5.0041880 PSIA
CALORIMETER CHANNEL 8 EXHAUST SATURATION PRESS. 5.1044170 PSIA
CALORIMETER CHANNEL 9 EXHAUST SATURATION PRESS. 4.3500880 PSIA
CALORIMETER CHANNEL 10 EXHAUST SATURATION PRESS. 3.9425560 PSIA
CALORIMETER CHANNEL 11 EXHAUST SATURATION PRESS. 5.5443660 PSIA

THE CALORIMETER EXHAUST PLENUM SATURATION PRESSURE .7759839 PSIA

COOLANT PRESSURE DROP ACROSS THRUST CHAMBER 231.5900000 PSID
COOLANT PRESSURE DROP ACROSS NOZZLE 51.0400400 PSID
CALORIMETER CHANNEL 1 PRESSURE DROP 1263.5900000 PSID
CALORIMETER CHANNEL 2 PRESSURE DROP 1339.3000000 PSID
CALORIMETER CHANNEL 3 PRESSURE DROP 1273.2600000 PSID
CALORIMETER CHANNEL 4 PRESSURE DROP 1356.5200000 PSID

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CALORIMETER CHANNEL  5 PRESSURE DROP    1393.7800000 PSID
CALORIMETER CHANNEL  6 PRESSURE DROP    1307.2200000 PSID
CALORIMETER CHANNEL  7 PRESSURE DROP    1278.5700000 PSID
CALORIMETER CHANNEL  8 PRESSURE DROP    1263.5200000 PSID
CALORIMETER CHANNEL  9 PRESSURE DROP    1325.1000000 PSID
CALORIMETER CHANNEL 10 PRESSURE DROP    1273.7500000 PSID
CALORIMETER CHANNEL 11 PRESSURE DROP    1333.6800000 PSID

COOLANT TEMP. RISE THROUGH THE THRUST CHAMBER     354.8600000 DEG F
COOLANT TEMP. RISE THROUGH THE NOZZLE      -107.3900000 DEG F
CALORIMETER CHANNEL  1 TEMP. RISE      82.7799700 DEG F
CALORIMETER CHANNEL  2 TEMP. RISE      79.0499900 DEG F
CALORIMETER CHANNEL  3 TEMP. RISE      84.0199600 DEG F
CALORIMETER CHANNEL  4 TEMP. RISE      85.6200000 DEG F
CALORIMETER CHANNEL  5 TEMP. RISE      87.2500000 DEG F
CALORIMETER CHANNEL  6 TEMP. RISE      91.9899900 DEG F
CALORIMETER CHANNEL  7 TEMP. RISE      94.2399900 DEG F
CALORIMETER CHANNEL  8 TEMP. RISE      95.0799600 DEG F
CALORIMETER CHANNEL  9 TEMP. RISE      88.3800000 DEG F
CALORIMETER CHANNEL 10 TEMP. RISE      84.3399700 DEG F
CALORIMETER CHANNEL 11 TEMP. RISE      98.6099900 DEG F

THRUST CHAMBER COOLANT JACKET RESISTANCE     115.5707000 S^2 PER FT^3-IN^2
NOZZLE COOLANT JACKET RESISTANCE       4.2023280 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL  1 RESISTANCE   20277.4300000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL  2 RESISTANCE   19783.1600000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL  3 RESISTANCE   19932.3300000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL  4 RESISTANCE   20680.0400000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL  5 RESISTANCE   22004.1600000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL  6 RESISTANCE   19700.6200000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL  7 RESISTANCE   18165.3600000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL  8 RESISTANCE   17798.0600000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL  9 RESISTANCE   19503.1600000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 10 RESISTANCE   21029.8900000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 11 RESISTANCE   21161.4300000 S^2 PER FT^3-IN^2
MAIN LOX VALVE RESISTANCE      972.3984000 S^2 PER FT^3-IN^2
MAIN FUEL VALVE RESISTANCE     1303.1010000 S^2 PER FT^3-IN^2

HEAT TRANSFER TO THE H2 IN THRUST CHAMBER     3646.7160000 BTU PER S
HEAT TRANSFER TO THE H2 IN NOZZLE    -1093.9400000 BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL  1     155.6225000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL  2     154.1761000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL  3     160.0299000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL  4     164.9300000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL  5     165.1067000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL  6     179.1284000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL  7     189.3281000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL  8     191.9713000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL  9     173.7297000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 10     156.4566000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 11     187.5301000BTU PER S

LOX DENSITY UPSTREAM OF MOV      69.1890500 LBM PER FT^3
LH2 DENSITY UPSTREAM OF MFV       4.7825600 LBM PER FT^  3
LH2 DENSITY INLET TO T.C. COOLANT JACKET        3.4366910 LBM PER FT^3
H2 DENSITY EXHAUST FROM T.C. COOLANT JACKET          .5743462 LBM PER FT^3
H2 DENSITY INLET TO NOZZLE COOLANT JACKET         .5670108 LBM PER FT^3
H2 DENSITY EXHAUST FROM NOZZLE COOLANT JACKET          .7160726 LBM PER FT^3
H2O DENSITY CALORIMETER INLET MANIFOLD       62.9936100 LBM PER FT^3
CALORIMETER CHANNEL  1 INLET DENSITY      62.8711200 LBM PER FT^3
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CALORIMETER CHANNEL 2 INLET DENSITY 62.8703900 LBM PER FT^3
CALORIMETER CHANNEL 3 INLET DENSITY 62.8497300 LBM PER FT^3
CALORIMETER CHANNEL 4 INLET DENSITY 62.8767600 LBM PER FT^3
CALORIMETER CHANNEL 5 INLET DENSITY 62.8872400 LBM PER FT^3
CALORIMETER CHANNEL 6 INLET DENSITY 62.8491300 LBM PER FT^3
CALORIMETER CHANNEL 7 INLET DENSITY 62.8566000 LBM PER FT^3
CALORIMETER CHANNEL 8 INLET DENSITY 62.8631500 LBM PER FT^3
CALORIMETER CHANNEL 9 INLET DENSITY 62.8564300 LBM PER FT^3
CALORIMETER CHANNEL 10 INLET DENSITY 62.8441500 LBM PER FT^3
CALORIMETER CHANNEL 11 INLET DENSITY 62.8672400 LBM PER FT^3
CALORIMETER CHANNEL 1 EXHAUST DENSITY 61.4729000 LBM PER FT^3
CALORIMETER CHANNEL 2 EXHAUST DENSITY 61.5282500 LBM PER FT^3
CALORIMETER CHANNEL 3 EXHAUST DENSITY 61.4266700 LBM PER FT^3
CALORIMETER CHANNEL 4 EXHAUST DENSITY 61.4070400 LBM PER FT^3
CALORIMETER CHANNEL 5 EXHAUST DENSITY 61.3789100 LBM PER FT^3
CALORIMETER CHANNEL 6 EXHAUST DENSITY 61.2645800 LBM PER FT^3
CALORIMETER CHANNEL 7 EXHAUST DENSITY 61.2323200 LBM PER FT^3
CALORIMETER CHANNEL 8 EXHAUST DENSITY 61.2246300 LBM PER FT^3
CALORIMETER CHANNEL 9 EXHAUST DENSITY 61.3394200 LBM PER FT^3
CALORIMETER CHANNEL 10 EXHAUST DENSITY 61.4150200 LBM PER FT^3
CALORIMETER CHANNEL 11 EXHAUST DENSITY 61.1439600 LBM PER FT^3

LH2 ENTHALPY INLET TO T.C. COOLANT JACKET 93.4148100 BTU PER LBM
GH2 ENTHALPY EXHAUST FROM T.C. COOLANT JACKET 1483.0340000 BTU PER LBM
GH2 ENTHALPY INLET TO NOZZLE COOLANT JACKET 1485.8810000 BTU PER LBM
GH2 ENTHALPY EXHAUST FROM NOZZLE COOLANT JACKET 1069.0240000 BTU PER LBM
CALORIMETER CHANNEL 1 INLET ENTHALPY 43.9887400 BTU PER LBM
CALORIMETER CHANNEL 2 INLET ENTHALPY 43.9774900 BTU PER LBM
CALORIMETER CHANNEL 3 INLET ENTHALPY 43.6776600 BTU PER LBM
CALORIMETER CHANNEL 4 INLET ENTHALPY 44.0710800 BTU PER LBM
CALORIMETER CHANNEL 5 INLET ENTHALPY 44.2224100 BTU PER LBM
CALORIMETER CHANNEL 6 INLET ENTHALPY 43.6698800 BTU PER LBM
CALORIMETER CHANNEL 7 INLET ENTHALPY 43.7783900 BTU PER LBM
CALORIMETER CHANNEL 8 INLET ENTHALPY 43.8726500 BTU PER LBM
CALORIMETER CHANNEL 9 INLET ENTHALPY 43.7753200 BTU PER LBM
CALORIMETER CHANNEL 10 INLET ENTHALPY 43.5972400 BTU PER LBM
CALORIMETER CHANNEL 11 INLET ENTHALPY 43.9321800 BTU PER LBM
CALORIMETER CHANNEL 1 EXHAUST ENTHALPY 122.6118000 BTU PER LBM
CALORIMETER CHANNEL 2 EXHAUST ENTHALPY 118.7088000 BTU PER LBM
CALORIMETER CHANNEL 3 EXHAUST ENTHALPY 123.5451000 BTU PER LBM
CALORIMETER CHANNEL 4 EXHAUST ENTHALPY 125.2825000 BTU PER LBM
CALORIMETER CHANNEL 5 EXHAUST ENTHALPY 126.9478000 BTU PER LBM
CALORIMETER CHANNEL 6 EXHAUST ENTHALPY 131.3862000 BTU PER LBM
CALORIMETER CHANNEL 7 EXHAUST ENTHALPY 133.7902000 BTU PER LBM
CALORIMETER CHANNEL 8 EXHAUST ENTHALPY 134.7454000 BTU PER LBM
CALORIMETER CHANNEL 9 EXHAUST ENTHALPY 127.8426000 BTU PER LBM
CALORIMETER CHANNEL 10 EXHAUST ENTHALPY 123.7905000 BTU PER LBM
CALORIMETER CHANNEL 11 EXHAUST ENTHALPY 138.1440000 BTU PER LBM

GOX VENTURI FLOW .0569646 LBM PER S
GH2 VENTURI FLOW .0558314 LBM PER S
LOX INJECTOR FLOW 11.5102900 LBM PER S
GH2 INJECTOR FLOW 2.6242560 LBM PER S
CALORIMETER CHANNEL 1 H2O FLOW 1.9793490 LBM PER S
CALORIMETER CHANNEL 2 H2O FLOW 2.0630710 LBM PER S
CALORIMETER CHANNEL 3 H2O FLOW 2.0036930 LBM PER S
CALORIMETER CHANNEL 4 H2O FLOW 2.0308720 LBM PER S
CALORIMETER CHANNEL 5 H2O FLOW 1.9958410 LBM PER S
CALORIMETER CHANNEL 6 H2O FLOW 2.0421330 LBM PER S
CALORIMETER CHANNEL 7 H2O FLOW 2.1033700 LBM PER S

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CALORIMETER CHANNEL  8 H2O FLOW          2.1125300 LBM PER S
CALORIMETER CHANNEL  9 H2O FLOW          2.0665540 LBM PER S
CALORIMETER CHANNEL 10 H2O FLOW          1.9509940 LBM PER S
CALORIMETER CHANNEL 11 H2O FLOW          1.9905150 LBM PER S

THE THEORETICAL CSTAR      8315.8290000
THE CSTAR     8163.6670000
CSTAR EFFICIENCY        98.1702100
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T = 211.0, MR:6.0 (VS. 4.9 ACTUAL)

LH2 PRESS. UPSTREAM OF THE MAIN FUEL VALVE 3452.0300000 PSIG
LH2 PRESS. DOWNSTREAM OF THE MAIN FUEL VALVE 1591.8800000 PSIG
LH2 PRESS. INLET TO THE THRUST CHAMBER COOLANT JACKET 1704.2100000 PSIG
H2 PRESS. EXHAUST FROM THE THRUST CHAMBER COOLING JACKET 1468.7200000 PSIG
H2 PRESS. INLET TO THE NOZZLE COOLING JACKET 1452.3500000 PSIG
H2 PRESS. EXHAUST FROM THE NOZZLE COOLING JACKET 1401.5100000 PSIG
H2 PRESS. EXHAUST FROM THE NOZZLE COOLING JACKET-REDUNDANT 1401.5100000PSIG
NO PRESSURE AT P8
H2 PRESS. INLET TO THE FUEL MANIFOLD 961.2200000 PSIG
GH2 PRESS. INLET TO THE OLD FUEL MANIFOLD 1648.6400000 PSIG
CALORIMETER CHANNEL 11 EXHAUST PRESSURE 1573.7300000 PSIG
CALORIMETER CHANNEL 12 EXHAUST PRESSURE 1503.7100000 PSIG
CALORIMETER CHANNEL 13 EXHAUST PRESSURE 1454.9300000 PSIG
CALORIMETER CHANNEL 14 EXHAUST PRESSURE 1515.7200000 PSIG
CALORIMETER CHANNEL 15 EXHAUST PRESSURE 1533.6000000 PSIG
CALORIMETER CHANNEL 16 EXHAUST PRESSURE 1419.0800000 PSIG
CALORIMETER CHANNEL 17 EXHAUST PRESSURE 1487.5700000 PSIG
CALORIMETER CHANNEL 18 EXHAUST PRESSURE 1537.7800000 PSIG
CALORIMETER CHANNEL 19 EXHAUST PRESSURE 1450.4300000 PSIG
CALORIMETER CHANNEL 20 EXHAUST PRESSURE 1419.9300000 PSIG
CALORIMETER CHANNEL 21 EXHAUST PRESSURE 1484.6500000 PSIG
LOX PRESS. INLET TO THE MAIN OXIDIZER VALVE 2722.6200000 PSIG
LOX PRESS. EXHAUST FROM THE MAIN OXIDIZER VALVE 903.5200000 PSIG
H2O PRESS. CALORIMETER INLET MANIFOLD 3488.4000000 PSIG
GOX PRESS. INLET TO THE IGNITER VENTURI 2220.9500000 PSIG
NO PRESSURE AT P26
GH2 PRESS. INLET TO THE IGNITER VENTURI 2010.5400000 PSIG
NO PRESSURE AT P28
LOX DOME HIGH FREQUENCY PRESSURE TRANSDUCER 2560.0000000 PSIG
CHAMBER PRESSURE 819.2100000 PSIG
CHAMBER PRESSURE 824.8300000 PSIG
IGNITER PRESSURE 854.3900000 PSIG
IGNITER PRESSURE 851.0700000 PSIG
GOX PRESS. EXHAUST FROM THE IGNITER VENTURI 866.2100000 PSIG
GH2 PRESS. EXHAUST FROM THE IGNITER VENTURI 949.9400000 PSIG
H2O PRESS. CALORIMETER EXHAUST PLENUM 759.3900000 PSIG
CALORIMETER CHANNEL 1 INLET PRESSURE 2848.0600000 PSIG
CALORIMETER CHANNEL 2 INLET PRESSURE 2877.9600000 PSIG
CALORIMETER CHANNEL 3 INLET PRESSURE 2813.5700000 PSIG
CALORIMETER CHANNEL 4 INLET PRESSURE 2781.9300000 PSIG
CALORIMETER CHANNEL 5 INLET PRESSURE 2937.5400000 PSIG
CALORIMETER CHANNEL 6 INLET PRESSURE 2739.0600000 PSIG
CALORIMETER CHANNEL 7 INLET PRESSURE 2777.3500000 PSIG
CALORIMETER CHANNEL 8 INLET PRESSURE 2811.5000000 PSIG
CALORIMETER CHANNEL 9 INLET PRESSURE 2824.2300000 PSIG
CALORIMETER CHANNEL 10 INLET PRESSURE 2686.9900000 PSIG
CALORIMETER CHANNEL 11 INLET PRESSURE 2830.8400000 PSIG

LH2 TEMP. UPSTREAM OF THE MAIN FUEL VALVE -375.0000000 DEG F
LH2 TEMP. DOWNSTREAM OF THE MAIN FUEL VALVE -375.0000000 DEG F
LH2 TEMP. INLET TO THE THRUST CHAMBER COOLING JACKET -364.7500000 DEG F
H2 TEMP. EXHAUST FROM THE THRUST CHAMBER COOLING JACKET 26.4700000 DEG F
H2 TEMP. INLET TO THE NOZZLE COOLING JACKET 28.2300000 DEG F
H2 TEMP. EXHAUST FROM THE NOZZLE COOLING JACKET 164.3000000 DEG F
LOX TEMP. INLET TO THE MAIN OXIDIZER VALVE -272.2500000 DEG F
LOX TEMP. EXHAUST FROM THE MAIN OXIDIZER VALVE -272.7500000 DEG F
H2 TEMP. INLET TO THE FUEL MANIFOLD -30.6700000 DEG F
GH2 TEMP. INLET TO THE OLD FUEL MANIFOLD 60.1400000 DEG F
CALORIMETER CHANNEL 11 EXHAUST TEMP. 156.9300000 DEG F
CALORIMETER CHANNEL 12 EXHAUST TEMP. 150.4100000 DEG F

CALORIMETER CHANNEL 13 EXHAUST TEMP.	156.9100000	DEG F
CALORIMETER CHANNEL 14 EXHAUST TEMP.	158.8800000	DEG F
CALORIMETER CHANNEL 15 EXHAUST TEMP.	159.9800000	DEG F
CALORIMETER CHANNEL 16 EXHAUST TEMP.	164.8900000	DEG F
CALORIMETER CHANNEL 17 EXHAUST TEMP.	167.7600000	DEG F
CALORIMETER CHANNEL 18 EXHAUST TEMP.	169.4500000	DEG F
CALORIMETER CHANNEL 19 EXHAUST TEMP.	161.6200000	DEG F
CALORIMETER CHANNEL 20 EXHAUST TEMP.	158.2800000	DEG F
CALORIMETER CHANNEL 21 EXHAUST TEMP.	176.3900000	DEG F
GOX TEMP. INLET TO THE IGNITER VENTURI	45.5300000	DEG F
GH2 TEMP. INLET TO THE IGNITER VENTURI	57.0500000	DEG F
H2O TEMP. CALORIMETER INLET MANIFOLD	64.0000000	DE G F
TEMP. MAIN OXIDIZER VALVE OPERATOR	32.6600000	DEG F
TEMP. MAIN FUEL VALVE OPERATOR	81.1800000	DEG F
H2O TEMP. CALORIMETER EXHAUST PLENUM	89.9500000	DE G F

LOX PRESS. UPSTREAM OF SYSTEM VENTURI	2757.4500000	P SIG
LOX PRESS. DOWNSTREAM OF SYSTEM VENTURI	2723.5800000	PSIG
LH2 PRESS. UPSTREAM OF SYSTEM VENTURI	3452.2700000	P SIG
LH2 PRESS. DOWNSTREAM OF SYSTEM VENTURI	3418.7900000	PSIG

LOX TEMP. UPSTREAM OF THE SYSTEM VENTURI	-275.5400000	DEG F
LH2 TEMP. UPSTREAM OF THE SYSTEM VENTURI	-380.6900000	DEG F

THE NOZZLE MIXTURE RATIO IS 3.9573940

THE INJECTOR MIXTURE RATIO IS 4.8783930

CORRECTED CALORIMETER CHANNEL 1 INLET PRESS.	2827.8600000	PSIG
CORRECTED CALORIMETER CHANNEL 2 INLET PRESS.	2866.5600000	PSIG
CORRECTED CALORIMETER CHANNEL 3 INLET PRESS.	2796.1700000	PSIG
CORRECTED CALORIMETER CHANNEL 4 INLET PRESS.	2763.7300000	PSIG
CORRECTED CALORIMETER CHANNEL 5 INLET PRESS.	2926.6400000	PSIG
CORRECTED CALORIMETER CHANNEL 6 INLET PRESS.	2732.4600000	PSIG
CORRECTED CALORIMETER CHANNEL 7 INLET PRESS.	2766.5500000	PSIG
CORRECTED CALORIMETER CHANNEL 8 INLET PRESS.	2799.3000000	PSIG
CORRECTED CALORIMETER CHANNEL 9 INLET PRESS.	2810.3300000	PSIG
CORRECTED CALORIMETER CHANNEL 10 INLET PRESS.	2674.1900000	PSIG
CORRECTED CALORIMETER CHANNEL 11 INLET PRESS.	2814.0400000	PSIG

CALORIMETER CHANNEL 1 EXHAUST SATURATION PRESS.	4.4082230	PSIA
CALORIMETER CHANNEL 2 EXHAUST SATURATION PRESS.	3.7595890	PSIA
CALORIMETER CHANNEL 3 EXHAUST SATURATION PRESS.	4.4061040	PSIA
CALORIMETER CHANNEL 4 EXHAUST SATURATION PRESS.	4.6196940	PSIA
CALORIMETER CHANNEL 5 EXHAUST SATURATION PRESS.	4.7427200	PSIA
CALORIMETER CHANNEL 6 EXHAUST SATURATION PRESS.	5.3261690	PSIA
CALORIMETER CHANNEL 7 EXHAUST SATURATION PRESS.	5.6944140	PSIA
CALORIMETER CHANNEL 8 EXHAUST SATURATION PRESS.	5.9211210	PSIA
CALORIMETER CHANNEL 9 EXHAUST SATURATION PRESS.	4.9312740	PSIA
CALORIMETER CHANNEL 10 EXHAUST SATURATION PRESS.	4.5537330	PSIA
CALORIMETER CHANNEL 11 EXHAUST SATURATION PRESS.	6.9334220	PSIA

THE CALORIMETER EXHAUST PLENUM SATURATION PRESSURE .6977708 PSIA

COOLANT PRESSURE DROP ACROSS THRUST CHAMBER	235.4900000	PSID
COOLANT PRESSURE DROP ACROSS NOZZLE	50.8399700	PSID
CALORIMETER CHANNEL 1 PRESSURE DROP	1254.1300000	PSID
CALORIMETER CHANNEL 2 PRESSURE DROP	1362.8500000	PSID
CALORIMETER CHANNEL 3 PRESSURE DROP	1341.2400000	PSID
CALORIMETER CHANNEL 4 PRESSURE DROP	1248.0100000	PSID

CALORIMETER CHANNEL 5 PRESSURE DROP   1393.0400000 PSID
CALORIMETER CHANNEL 6 PRESSURE DROP   1313.3800000 PSID
CALORIMETER CHANNEL 7 PRESSURE DROP   1278.9800000 PSID
CALORIMETER CHANNEL 8 PRESSURE DROP   1261.5200000 PSID
CALORIMETER CHANNEL 9 PRESSURE DROP   1359.9000000 PSID
CALORIMETER CHANNEL 10 PRESSURE DROP   1254.2600000 PSID
CALORIMETER CHANNEL 11 PRESSURE DROP   1329.3900000 PSID

COOLANT TEMP. RISE THROUGH THE THRUST CHAMBER   391.2200000 DEG F
COOLANT TEMP. RISE THROUGH THE NOZZLE   136.0700000 DEG F
CALORIMETER CHANNEL 1 TEMP. RISE   92.9299300 DEG F
CALORIMETER CHANNEL 2 TEMP. RISE   86.4099700 DEG F
CALORIMETER CHANNEL 3 TEMP. RISE   92.9099700 DEG F
CALORIMETER CHANNEL 4 TEMP. RISE   94.8800000 DEG F
CALORIMETER CHANNEL 5 TEMP. RISE   95.9799800 DEG F
CALORIMETER CHANNEL 6 TEMP. RISE   100.8900000 DEG F
CALORIMETER CHANNEL 7 TEMP. RISE   103.7599000 DEG F
CALORIMETER CHANNEL 8 TEMP. RISE   105.4500000 DEG F
CALORIMETER CHANNEL 9 TEMP. RISE   97.6200000 DEG F
CALORIMETER CHANNEL 10 TEMP. RISE   94.2799700 DEG F
CALORIMETER CHANNEL 11 TEMP. RISE   112.3900000 DEG F

THRUST CHAMBER COOLANT JACKET RESISTANCE   124.3983000 S^2 PER FT^3-IN^2
NOZZLE COOLANT JACKET RESISTANCE   4.2349890 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 1 RESISTANCE   19851.9600000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 2 RESISTANCE   21249.4900000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 3 RESISTANCE   23262.5900000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 4 RESISTANCE   16250.1300000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 5 RESISTANCE   22178.1200000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 6 RESISTANCE   20110.8000000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 7 RESISTANCE   18340.9300000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 8 RESISTANCE   17899.5300000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 9 RESISTANCE   21571.2300000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 10 RESISTANCE   20193.3300000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 11 RESISTANCE   21027.4500000 S^2 PER FT^3-IN^2
MAIN LOX VALVE RESISTANCE   809.4789000 S^2 PER FT^3-IN^2
MAIN FUEL VALVE RESISTANCE   1311.4810000 S^2 PER FT^3-IN^2

HEAT TRANSFER TO THE H2 IN THRUST CHAMBER   3848.0560000 BTU PER S
HEAT TRANSFER TO THE H2 IN NOZZLE   1236.1350000 BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 1   176.8346000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 2   164.6030000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 3   168.5093000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 4   199.2993000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 5   181.6499000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 6   195.6023000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 7   208.2664000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 8   212.9901000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 9   185.4414000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 10   178.0603000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 11   215.1903000BTU PER S

LOX DENSITY UPSTREAM OF MOV   69.7651500 LBM PER FT^3
LH2 DENSITY UPSTREAM OF MFV   4.4865690 LBM PER FT^ 3
LH2 DENSITY INLET TO T.C. COOLANT JACKET   3.3615710 LBM PER FT^3
H2 DENSITY EXHAUST FROM T.C. COOLANT JACKET   .5374907 LBM PER FT^3
H2 DENSITY INLET TO NOZZLE COOLANT JACKET   .5300874 LBM PER FT^3
H2 DENSITY EXHAUST FROM NOZZLE COOLANT JACKET   .4045229 LBM PER FT^3
H2O DENSITY CALORIMETER INLET MANIFOLD   63.0251600 LBM PER FT^3
CALORIMETER CHANNEL 1 INLET DENSITY   62.8999200 LBM PER FT^3

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CALORIMETER CHANNEL  2 INLET DENSITY       62.9072800 LBM PER FT^3
CALORIMETER CHANNEL  3 INLET DENSITY       62.8939000 LBM PER FT^3
CALORIMETER CHANNEL  4 INLET DENSITY       62.8877000 LBM PER FT^3
CALORIMETER CHANNEL  5 INLET DENSITY       62.9187000 LBM PER FT^3
CALORIMETER CHANNEL  6 INLET DENSITY       62.8817100 LBM PER FT^3
CALORIMETER CHANNEL  7 INLET DENSITY       62.8882500 LBM PER FT^3
CALORIMETER CHANNEL  8 INLET DENSITY       62.8944500 LBM PER FT^3
CALORIMETER CHANNEL  9 INLET DENSITY       62.8965900 LBM PER FT^3
CALORIMETER CHANNEL 10 INLET DENSITY       62.8706200 LBM PER FT^3
CALORIMETER CHANNEL 11 INLET DENSITY       62.8972700 LBM PER FT^3
CALORIMETER CHANNEL  1 EXHAUST DENSITY       61.3541100 LBM PER FT^3
CALORIMETER CHANNEL  2 EXHAUST DENSITY       61.4666300 LBM PER FT^3
CALORIMETER CHANNEL  3 EXHAUST DENSITY       61.3325400 LBM PER FT^3
CALORIMETER CHANNEL  4 EXHAUST DENSITY       61.3050700 LBM PER FT^3
CALORIMETER CHANNEL  5 EXHAUST DENSITY       61.2866200 LBM PER FT^3
CALORIMETER CHANNEL  6 EXHAUST DENSITY       61.1667400 LBM PER FT^3
CALORIMETER CHANNEL  7 EXHAUST DENSITY       61.1208000 LBM PER FT^3
CALORIMETER CHANNEL  8 EXHAUST DENSITY       61.0953200 LBM PER FT^3
CALORIMETER CHANNEL  9 EXHAUST DENSITY       61.2384700 LBM PER FT^3
CALORIMETER CHANNEL 10 EXHAUST DENSITY       61.2991100 LBM PER FT^3
CALORIMETER CHANNEL 11 EXHAUST DENSITY       60.9393600 LBM PER FT^3

LH2 ENTHALPY INLET TO T.C. COOLANT JACKET      103.7786000 BTU PER LBM
GH2 ENTHALPY EXHAUST FROM T.C. COOLANT JACKET     1629.2050000 BTU PER LBM
GH2 ENTHALPY INLET TO NOZZLE COOLANT JACKET     1635.4590000 BTU PER LBM
GH2 ENTHALPY EXHAUST FROM NOZZLE COOLANT JACKET     2125.4810000 BTU PER LBM
CALORIMETER CHANNEL  1 INLET ENTHALPY      40.0130100 BTU PER LBM
CALORIMETER CHANNEL  2 INLET ENTHALPY      40.1203400 BTU PER LBM
CALORIMETER CHANNEL  3 INLET ENTHALPY      39.9251700 BTU PER LBM
CALORIMETER CHANNEL  4 INLET ENTHALPY      39.8362000 BTU PER LBM
CALORIMETER CHANNEL  5 INLET ENTHALPY      40.2857800 BTU PER LBM
CALORIMETER CHANNEL  6 INLET ENTHALPY      39.7499000 BTU PER LBM
CALORIMETER CHANNEL  7 INLET ENTHALPY      39.8436700 BTU PER LBM
CALORIMETER CHANNEL  8 INLET ENTHALPY      39.9343100 BTU PER LBM
CALORIMETER CHANNEL  9 INLET ENTHALPY      39.9651200 BTU PER LBM
CALORIMETER CHANNEL 10 INLET ENTHALPY      39.5878700 BTU PER LBM
CALORIMETER CHANNEL 11 INLET ENTHALPY      39.9748600 BTU PER LBM
CALORIMETER CHANNEL  1 EXHAUST ENTHALPY      128.7230000 BTU PER LBM
CALORIMETER CHANNEL  2 EXHAUST ENTHALPY      122.0682000 BTU PER LBM
CALORIMETER CHANNEL  3 EXHAUST ENTHALPY      128.4154000 BTU PER LBM
CALORIMETER CHANNEL  4 EXHAUST ENTHALPY      130.5226000 BTU PER LBM
CALORIMETER CHANNEL  5 EXHAUST ENTHALPY      131.6605000 BTU PER LBM
CALORIMETER CHANNEL  6 EXHAUST ENTHALPY      136.2730000 BTU PER LBM
CALORIMETER CHANNEL  7 EXHAUST ENTHALPY      139.2956000 BTU PER LBM
CALORIMETER CHANNEL  8 EXHAUST ENTHALPY      141.0985000 BTU PER LBM
CALORIMETER CHANNEL  9 EXHAUST ENTHALPY      133.0925000 BTU PER LBM
CALORIMETER CHANNEL 10 EXHAUST ENTHALPY      129.6938000 BTU PER LBM
CALORIMETER CHANNEL 11 EXHAUST ENTHALPY      147.8879000 BTU PER LBM

GOX VENTURI FLOW          .0558659 LBM PER S
GH2 VENTURI FLOW          .0554993 LBM PER S
LOX INJECTOR FLOW       12.5211700 LBM PER S
GH2 INJECTOR FLOW        2.5226110 LBM PER S
CALORIMETER CHANNEL  1 H2O FLOW        1.9934010 LBM PER S
CALORIMETER CHANNEL  2 H2O FLOW        2.0086320 LBM PER S
CALORIMETER CHANNEL  3 H2O FLOW        1.9042700 LBM PER S
CALORIMETER CHANNEL  4 H2O FLOW        2.1976750 LBM PER S
CALORIMETER CHANNEL  5 H2O FLOW        1.9879680 LBM PER S
CALORIMETER CHANNEL  6 H2O FLOW        2.0264820 LBM PER S
CALORIMETER CHANNEL  7 H2O FLOW        2.0941410 LBM PER S
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CALORIMETER CHANNEL 8 H2O FLOW	2.1053900	LBM PER S
CALORIMETER CHANNEL 9 H2O FLOW	1.9912670	LBM PER S
CALORIMETER CHANNEL 10 H2O FLOW	1.9761210	LBM PER S
CALORIMETER CHANNEL 11 H2O FLOW	1.9941090	LBM PER S

THE THEORETICAL CSTAR 8235.0290000
THE CSTAR 8132.0590000
CSTAR EFFICIENCY 98.7496100

T = 214.0, MR:6.5 (VS. 5.3 ACTUAL)

LH2 PRESS. UPSTREAM OF THE MAIN FUEL VALVE 3454.6800000 PSIG
LH2 PRESS. DOWNSTREAM OF THE MAIN FUEL VALVE 1551.9400000 PSIG
LH2 PRESS. INLET TO THE THRUST CHAMBER COOLANT JACKET 1648.5900000 PSIG
H2 PRESS. EXHAUST FROM THE THRUST CHAMBER COOLING JACKET 1422.9300000 PSIG
H2 PRESS. INLET TO THE NOZZLE COOLING JACKET 1407.1200000 PSIG
H2 PRESS. EXHAUST FROM THE NOZZLE COOLING JACKET 1358.2900000 PSIG
H2 PRESS. EXHAUST FROM THE NOZZLE COOLING JACKET-REDUNDANT 1358.2900000PSIG
NO PRESSURE AT P8
H2 PRESS. INLET TO THE FUEL MANIFOLD 955.1700000 PSIG
GH2 PRESS. INLET TO THE OLD FUEL MANIFOLD 1649.3200000 PSIG
CALORIMETER CHANNEL 11 EXHAUST PRESSURE 1576.3300000 PSIG
CALORIMETER CHANNEL 12 EXHAUST PRESSURE 1496.6900000 PSIG
CALORIMETER CHANNEL 13 EXHAUST PRESSURE 1453.0700000 PSIG
CALORIMETER CHANNEL 14 EXHAUST PRESSURE 1511.9800000 PSIG
CALORIMETER CHANNEL 15 EXHAUST PRESSURE 1531.4100000 PSIG
CALORIMETER CHANNEL 16 EXHAUST PRESSURE 1414.9600000 PSIG
CALORIMETER CHANNEL 17 EXHAUST PRESSURE 1485.1200000 PSIG
CALORIMETER CHANNEL 18 EXHAUST PRESSURE 1536.9600000 PSIG
CALORIMETER CHANNEL 19 EXHAUST PRESSURE 1448.6100000 PSIG
CALORIMETER CHANNEL 20 EXHAUST PRESSURE 1421.8500000 PSIG
CALORIMETER CHANNEL 21 EXHAUST PRESSURE 1483.9300000 PSIG
LOX PRESS. INLET TO THE MAIN OXIDIZER VALVE 2721.3600000 PSIG
LOX PRESS. EXHAUST FROM THE MAIN OXIDIZER VALVE 913.5000000 PSIG
H2O PRESS. CALORIMETER INLET MANIFOLD 3482.4700000 PSIG
GOX PRESS. INLET TO THE IGNITER VENTURI 2193.1900000 PSIG
NO PRESSURE AT P26
GH2 PRESS. INLET TO THE IGNITER VENTURI 2002.7600000 PSIG
NO PRESSURE AT P28
LOX DOME HIGH FREQUENCY PRESSURE TRANSDUCER 2560.0000000 PSIG
CHAMBER PRESSURE 820.6800000 PSIG
CHAMBER PRESSURE 826.4500000 PSIG
IGNITER PRESSURE 855.4800000 PSIG
IGNITER PRESSURE 852.7900000 PSIG
GOX PRESS. EXHAUST FROM THE IGNITER VENTURI 867.3800000 PSIG
GH2 PRESS. EXHAUST FROM THE IGNITER VENTURI 950.8600000 PSIG
H2O PRESS. CALORIMETER EXHAUST PLENUM 758.3900000 PSIG
CALORIMETER CHANNEL 1 INLET PRESSURE 2864.8600000 PSIG
CALORIMETER CHANNEL 2 INLET PRESSURE 2846.9400000 PSIG
CALORIMETER CHANNEL 3 INLET PRESSURE 2864.2400000 PSIG
CALORIMETER CHANNEL 4 INLET PRESSURE 2829.7500000 PSIG
CALORIMETER CHANNEL 5 INLET PRESSURE 2932.0000000 PSIG
CALORIMETER CHANNEL 6 INLET PRESSURE 2720.2700000 PSIG
CALORIMETER CHANNEL 7 INLET PRESSURE 2770.5400000 PSIG
CALORIMETER CHANNEL 8 INLET PRESSURE 2805.3500000 PSIG
CALORIMETER CHANNEL 9 INLET PRESSURE 2824.3100000 PSIG
CALORIMETER CHANNEL 10 INLET PRESSURE 2696.2600000 PSIG
CALORIMETER CHANNEL 11 INLET PRESSURE 2829.4400000 PSIG

LH2 TEMP. UPSTREAM OF THE MAIN FUEL VALVE -380.0000000 DEG F
LH2 TEMP. DOWNSTREAM OF THE MAIN FUEL VALVE -380.0000000 DEG F
LH2 TEMP. INLET TO THE THRUST CHAMBER COOLING JACKET -364.5000000 DEG F
H2 TEMP. EXHAUST FROM THE THRUST CHAMBER COOLING JACKET 64.6700000 DEG F
H2 TEMP. INLET TO THE NOZZLE COOLING JACKET 66.4500000 DEG F
H2 TEMP. EXHAUST FROM THE NOZZLE COOLING JACKET 206.7700000 DEG F
LOX TEMP. INLET TO THE MAIN OXIDIZER VALVE -273.4900000 DEG F
LOX TEMP. EXHAUST FROM THE MAIN OXIDIZER VALVE -273.4900000 DEG F
H2 TEMP. INLET TO THE FUEL MANIFOLD -78.7600000 DEG F
GH2 TEMP. INLET TO THE OLD FUEL MANIFOLD 60.9400000 DEG F
CALORIMETER CHANNEL 11 EXHAUST TEMP. 158.0200000 DEG F
CALORIMETER CHANNEL 12 EXHAUST TEMP. 151.9100000 DEG F

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CALORIMETER CHANNEL 13 EXHAUST TEMP.      158.0800000 DEG F
CALORIMETER CHANNEL 14 EXHAUST TEMP.      159.9900000 DEG F
CALORIMETER CHANNEL 15 EXHAUST TEMP.      161.4700000 DEG F
CALORIMETER CHANNEL 16 EXHAUST TEMP.      167.0800000 DEG F
CALORIMETER CHANNEL 17 EXHAUST TEMP.      169.9700000 DEG F
CALORIMETER CHANNEL 18 EXHAUST TEMP.      171.6400000 DEG F
CALORIMETER CHANNEL 19 EXHAUST TEMP.      163.6100000 DEG F
CALORIMETER CHANNEL 20 EXHAUST TEMP.      160.0500000 DEG F
CALORIMETER CHANNEL 21 EXHAUST TEMP.      180.0300000 DEG F
GOX TEMP. INLET TO THE IGNITER VENTURI       46.0300000 DEG F
GH2 TEMP. INLET TO THE IGNITER VENTURI       57.6300000 DEG F
H2O TEMP. CALORIMETER INLET MANIFOLD       64.0000000 DE  G F
TEMP. MAIN OXIDIZER VALVE OPERATOR     32.9100000 DEG F
TEMP. MAIN FUEL VALVE OPERATOR    79.7400000 DEG F
H2O TEMP. CALORIMETER EXHAUST PLENUM       90.4100000 DE G F

LOX PRESS. UPSTREAM OF SYSTEM VENTURI     2757.0100000 P  SIG
LOX PRESS. DOWNSTREAM OF SYSTEM VENTURI     2721.2800000 PSIG
LH2 PRESS. UPSTREAM OF SYSTEM VENTURI     3452.4600000 P  SIG
LH2 PRESS. DOWNSTREAM OF SYSTEM VENTURI     3422.9500000 PSIG

LOX TEMP. UPSTREAM OF THE SYSTEM VENTURI     -277.6000000 DEG F
LH2 TEMP. UPSTREAM OF THE SYSTEM VENTURI     -379.9300000 DEG F

THE NOZZLE MIXTURE RATIO IS        4.2379700

THE INJECTOR MIXTURE RATIO IS        5.2751410

CORRECTED CALORIMETER CHANNEL  1 INLET PRESS.   2844.6600000 PSIG
CORRECTED CALORIMETER CHANNEL  2 INLET PRESS.   2835.5400000 PSIG
CORRECTED CALORIMETER CHANNEL  3 INLET PRESS.   2846.8400000 PSIG
CORRECTED CALORIMETER CHANNEL  4 INLET PRESS.   2811.5500000 PSIG
CORRECTED CALORIMETER CHANNEL  5 INLET PRESS.   2921.1000000 PSIG
CORRECTED CALORIMETER CHANNEL  6 INLET PRESS.   2713.6700000 PSIG
CORRECTED CALORIMETER CHANNEL  7 INLET PRESS.   2759.7400000 PSIG
CORRECTED CALORIMETER CHANNEL  8 INLET PRESS.   2793.1500000 PSIG
CORRECTED CALORIMETER CHANNEL  9 INLET PRESS.   2810.4100000 PSIG
CORRECTED CALORIMETER CHANNEL 10 INLET PRESS.   2683.4600000 PSIG
CORRECTED CALORIMETER CHANNEL 11 INLET PRESS.   2812.6400000 PSIG

CALORIMETER CHANNEL  1 EXHAUST SATURATION PRESS.       4.5253970 PSIA
CALORIMETER CHANNEL  2 EXHAUST SATURATION PRESS.       3.9011520 PSIA
CALORIMETER CHANNEL  3 EXHAUST SATURATION PRESS.       4.5319210 PSIA
CALORIMETER CHANNEL  4 EXHAUST SATURATION PRESS.       4.7438530 PSIA
CALORIMETER CHANNEL  5 EXHAUST SATURATION PRESS.       4.9137670 PSIA
CALORIMETER CHANNEL  6 EXHAUST SATURATION PRESS.       5.6052810 PSIA
CALORIMETER CHANNEL  7 EXHAUST SATURATION PRESS.       5.9923890 PSIA
CALORIMETER CHANNEL  8 EXHAUST SATURATION PRESS.       6.2261610 PSIA
CALORIMETER CHANNEL  9 EXHAUST SATURATION PRESS.       5.1685330 PSIA
CALORIMETER CHANNEL 10 EXHAUST SATURATION PRESS.       4.7506390 PSIA
CALORIMETER CHANNEL 11 EXHAUST SATURATION PRESS.       7.5200090 PSIA

THE CALORIMETER EXHAUST PLENUM SATURATION PRESSURE        .7079054 PSIA

COOLANT PRESSURE DROP ACROSS THRUST CHAMBER     225.6599000 PSID
COOLANT PRESSURE DROP ACROSS NOZZLE       48.8299600 PSID
CALORIMETER CHANNEL  1 PRESSURE DROP    1268.3300000 PSID
CALORIMETER CHANNEL  2 PRESSURE DROP    1338.8500000 PSID
CALORIMETER CHANNEL  3 PRESSURE DROP    1393.7700000 PSID
CALORIMETER CHANNEL  4 PRESSURE DROP    1299.5700000 PSID
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CALORIMETER CHANNEL  5 PRESSURE DROP     1389.6900000 PSID
CALORIMETER CHANNEL  6 PRESSURE DROP     1298.7100000 PSID
CALORIMETER CHANNEL  7 PRESSURE DROP     1274.6200000 PSID
CALORIMETER CHANNEL  8 PRESSURE DROP     1256.1900000 PSID
CALORIMETER CHANNEL  9 PRESSURE DROP     1361.8000000 PSID
CALORIMETER CHANNEL 10 PRESSURE DROP     1261.6100000 PSID
CALORIMETER CHANNEL 11 PRESSURE DROP     1328.7100000 PSID

COOLANT TEMP. RISE THROUGH THE THRUST CHAMBER      429.1700000 DEG F
COOLANT TEMP. RISE THROUGH THE NOZZLE      140.3200000 DEG F
CALORIMETER CHANNEL  1 TEMP. RISE       94.0199600 DEG F
CALORIMETER CHANNEL  2 TEMP. RISE       87.9099700 DEG F
CALORIMETER CHANNEL  3 TEMP. RISE       94.0799600 DEG F
CALORIMETER CHANNEL  4 TEMP. RISE       95.9899900 DEG F
CALORIMETER CHANNEL  5 TEMP. RISE       97.4699700 DEG F
CALORIMETER CHANNEL  6 TEMP. RISE      103.0800000 DEG F
CALORIMETER CHANNEL  7 TEMP. RISE      105.9700000 DEG F
CALORIMETER CHANNEL  8 TEMP. RISE      107.6400000 DEG F
CALORIMETER CHANNEL  9 TEMP. RISE       99.6099900 DEG F
CALORIMETER CHANNEL 10 TEMP. RISE       96.0499900 DEG F
CALORIMETER CHANNEL 11 TEMP. RISE      116.0300000 DEG F

THRUST CHAMBER COOLANT JACKET RESISTANCE     129.9307000 S^2 PER FT^3-IN^2
NOZZLE COOLANT JACKET RESISTANCE      4.0697660 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL  1 RESISTANCE   20817.0800000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL  2 RESISTANCE   20049.6500000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL  3 RESISTANCE   26391.3400000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL  4 RESISTANCE   18317.9200000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL  5 RESISTANCE   22140.5100000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL  6 RESISTANCE   19549.8900000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL  7 RESISTANCE   18255.7800000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL  8 RESISTANCE   17818.1200000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL  9 RESISTANCE   21799.0400000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 10 RESISTANCE   20705.3300000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 11 RESISTANCE   21162.7900000 S^2 PER FT^3-IN^2
MAIN LOX VALVE RESISTANCE      762.5961000 S^2 PER FT^3-IN^2
MAIN FUEL VALVE RESISTANCE     1521.9810000 S^2 PER FT^3-IN^2

HEAT TRANSFER TO THE H2 IN THRUST CHAMBER     3986.0800000 BTU PER S
HEAT TRANSFER TO THE H2 IN NOZZLE     1198.0220000 BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL  1     175.7098000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL  2     171.1486000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL  3     163.1435000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL  4     193.6015000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL  5     184.5502000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL  6     201.8155000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL  7     213.0333000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL  8     217.6472000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL  9     188.5174000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 10     179.7684000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 11     221.6628000BTU PER S

LOX DENSITY UPSTREAM OF MOV      69.9528400 LBM PER FT^3
LH2 DENSITY UPSTREAM OF MFV       4.5934920 LBM PER FT^  3
LH2 DENSITY INLET TO T.C. COOLANT JACKET       3.3065160 LBM PER FT^3
H2 DENSITY EXHAUST FROM T.C. COOLANT JACKET       .4852155 LBM PER FT^3
H2 DENSITY INLET TO NOZZLE COOLANT JACKET      .4786260 LBM PER FT^3
H2 DENSITY EXHAUST FROM NOZZLE COOLANT JACKET      .3685979 LBM PER FT^3
H2O DENSITY CALORIMETER INLET MANIFOLD      63.0239800 LBM PER FT^3
CALORIMETER CHANNEL  1 INLET DENSITY      62.9031300 LBM PER FT^3
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CALORIMETER CHANNEL  2 INLET DENSITY      62.9014100 LBM PER FT^3
CALORIMETER CHANNEL  3 INLET DENSITY      62.9035300 LBM PER FT^3
CALORIMETER CHANNEL  4 INLET DENSITY      62.8967800 LBM PER FT^3
CALORIMETER CHANNEL  5 INLET DENSITY      62.9176800 LBM PER FT^3
CALORIMETER CHANNEL  6 INLET DENSITY      62.8781400 LBM PER FT^3
CALORIMETER CHANNEL  7 INLET DENSITY      62.8869800 LBM PER FT^3
CALORIMETER CHANNEL  8 INLET DENSITY      62.8933100 LBM PER FT^3
CALORIMETER CHANNEL  9 INLET DENSITY      62.8966000 LBM PER FT^3
CALORIMETER CHANNEL 10 INLET DENSITY      62.8724000 LBM PER FT^3
CALORIMETER CHANNEL 11 INLET DENSITY      62.8970600 LBM PER FT^3
CALORIMETER CHANNEL  1 EXHAUST DENSITY      61.3332700 LBM PER FT^3
CALORIMETER CHANNEL  2 EXHAUST DENSITY      61.4368600 LBM PER FT^3
CALORIMETER CHANNEL  3 EXHAUST DENSITY      61.3092500 LBM PER FT^3
CALORIMETER CHANNEL  4 EXHAUST DENSITY      61.2824600 LBM PER FT^3
CALORIMETER CHANNEL  5 EXHAUST DENSITY      61.2565800 LBM PER FT^3
CALORIMETER CHANNEL  6 EXHAUST DENSITY      61.1212200 LBM PER FT^3
CALORIMETER CHANNEL  7 EXHAUST DENSITY      61.0746700 LBM PER FT^3
CALORIMETER CHANNEL  8 EXHAUST DENSITY      61.0496100 LBM PER FT^3
CALORIMETER CHANNEL  9 EXHAUST DENSITY      61.1981800 LBM PER FT^3
CALORIMETER CHANNEL 10 EXHAUST DENSITY      61.2644800 LBM PER FT^3
CALORIMETER CHANNEL 11 EXHAUST DENSITY      60.8609100 LBM PER FT^3

LH2 ENTHALPY INLET TO T.C. COOLANT JACKET      104.3979000 BTU PER LBM
GH2 ENTHALPY EXHAUST FROM T.C. COOLANT JACKET     1767.7700000 BTU PER LBM
GH2 ENTHALPY INLET TO NOZZLE COOLANT JACKET     1773.9950000 BTU PER LBM
GH2 ENTHALPY EXHAUST FROM NOZZLE COOLANT JACKET     2273.9240000 BTU PER LBM
CALORIMETER CHANNEL  1 INLET ENTHALPY      40.0595900 BTU PER LBM
CALORIMETER CHANNEL  2 INLET ENTHALPY      40.0342300 BTU PER LBM
CALORIMETER CHANNEL  3 INLET ENTHALPY      40.0657600 BTU PER LBM
CALORIMETER CHANNEL  4 INLET ENTHALPY      39.9679800 BTU PER LBM
CALORIMETER CHANNEL  5 INLET ENTHALPY      40.2707900 BTU PER LBM
CALORIMETER CHANNEL  6 INLET ENTHALPY      39.6982300 BTU PER LBM
CALORIMETER CHANNEL  7 INLET ENTHALPY      39.8248800 BTU PER LBM
CALORIMETER CHANNEL  8 INLET ENTHALPY      39.9176300 BTU PER LBM
CALORIMETER CHANNEL  9 INLET ENTHALPY      39.9651100 BTU PER LBM
CALORIMETER CHANNEL 10 INLET ENTHALPY      39.6141400 BTU PER LBM
CALORIMETER CHANNEL 11 INLET ENTHALPY      39.9711600 BTU PER LBM
CALORIMETER CHANNEL  1 EXHAUST ENTHALPY      129.8135000 BTU PER LBM
CALORIMETER CHANNEL  2 EXHAUST ENTHALPY      123.5427000 BTU PER LBM
CALORIMETER CHANNEL  3 EXHAUST ENTHALPY      129.5749000 BTU PER LBM
CALORIMETER CHANNEL  4 EXHAUST ENTHALPY      131.6180000 BTU PER LBM
CALORIMETER CHANNEL  5 EXHAUST ENTHALPY      133.1381000 BTU PER LBM
CALORIMETER CHANNEL  6 EXHAUST ENTHALPY      138.4445000 BTU PER LBM
CALORIMETER CHANNEL  7 EXHAUST ENTHALPY      141.4911000 BTU PER LBM
CALORIMETER CHANNEL  8 EXHAUST ENTHALPY      143.2780000 BTU PER LBM
CALORIMETER CHANNEL  9 EXHAUST ENTHALPY      135.0693000 BTU PER LBM
CALORIMETER CHANNEL 10 EXHAUST ENTHALPY      131.4605000 BTU PER LBM
CALORIMETER CHANNEL 11 EXHAUST ENTHALPY      151.5159000 BTU PER LBM

GOX VENTURI FLOW      .0551141 LBM PER S
GH2 VENTURI FLOW      .0552649 LBM PER S
LOX INJECTOR FLOW    12.8776900 LBM PER S
GH2 INJECTOR FLOW     2.3963850 LBM PER S
CALORIMETER CHANNEL  1 H2O FLOW      1.9576830 LBM PER S
CALORIMETER CHANNEL  2 H2O FLOW      2.0494760 LBM PER S
CALORIMETER CHANNEL  3 H2O FLOW      1.8226460 LBM PER S
CALORIMETER CHANNEL  4 H2O FLOW      2.1123990 LBM PER S
CALORIMETER CHANNEL  5 H2O FLOW      1.9872460 LBM PER S
CALORIMETER CHANNEL  6 H2O FLOW      2.0437780 LBM PER S
CALORIMETER CHANNEL  7 H2O FLOW      2.0954170 LBM PER S
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CALORIMETER CHANNEL  8 H2O FLOW        2.1057120 LBM PER S
CALORIMETER CHANNEL  9 H2O FLOW        1.9822190 LBM PER S
CALORIMETER CHANNEL 10 H2O FLOW        1.9572730 LBM PER S
CALORIMETER CHANNEL 11 H2O FLOW        1.9872100 LBM PER S

THE THEORETICAL CSTAR    8173.6420000
THE CSTAR    8031.0120000
CSTAR EFFICIENCY      98.2550000
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T = 217.0, MR:7.0 (VS. 5.8 ACTUAL)

LH2 PRESS. UPSTREAM OF THE MAIN FUEL VALVE 3456.6300000 PSIG
LH2 PRESS. DOWNSTREAM OF THE MAIN FUEL VALVE 1535.8700000 PSIG
LH2 PRESS. INLET TO THE THRUST CHAMBER COOLANT JACKET 1620.8000000 PSIG
H2 PRESS. EXHAUST FROM THE THRUST CHAMBER COOLING JACKET 1405.3600000 PSIG
H2 PRESS. INLET TO THE NOZZLE COOLING JACKET 1389.4400000 PSIG
H2 PRESS. EXHAUST FROM THE NOZZLE COOLING JACKET 1341.5600000 PSIG
H2 PRESS. EXHAUST FROM THE NOZZLE COOLING JACKET-REDUNDANT 1341.5600000PSIG
NO PRESSURE AT P8
H2 PRESS. INLET TO THE FUEL MANIFOLD 954.6700000 PSIG
GH2 PRESS. INLET TO THE OLD FUEL MANIFOLD 1634.5000000 PSIG
CALORIMETER CHANNEL 11 EXHAUST PRESSURE 1571.1200000 PSIG
CALORIMETER CHANNEL 12 EXHAUST PRESSURE 1497.7000000 PSIG
CALORIMETER CHANNEL 13 EXHAUST PRESSURE 1452.5600000 PSIG
CALORIMETER CHANNEL 14 EXHAUST PRESSURE 1512.7800000 PSIG
CALORIMETER CHANNEL 15 EXHAUST PRESSURE 1530.6100000 PSIG
CALORIMETER CHANNEL 16 EXHAUST PRESSURE 1416.3100000 PSIG
CALORIMETER CHANNEL 17 EXHAUST PRESSURE 1484.2100000 PSIG
CALORIMETER CHANNEL 18 EXHAUST PRESSURE 1537.4700000 PSIG
CALORIMETER CHANNEL 19 EXHAUST PRESSURE 1442.3900000 PSIG
CALORIMETER CHANNEL 20 EXHAUST PRESSURE 1422.2500000 PSIG
CALORIMETER CHANNEL 21 EXHAUST PRESSURE 1482.7800000 PSIG
LOX PRESS. INLET TO THE MAIN OXIDIZER VALVE 2717.9100000 PSIG
LOX PRESS. EXHAUST FROM THE MAIN OXIDIZER VALVE 924.0500000 PSIG
H2O PRESS. CALORIMETER INLET MANIFOLD 3483.6800000 PSIG
GOX PRESS. INLET TO THE IGNITER VENTURI 2166.3500000 PSIG
NO PRESSURE AT P26
GH2 PRESS. INLET TO THE IGNITER VENTURI 1995.7700000 PSIG
NO PRESSURE AT P28
LOX DOME HIGH FREQUENCY PRESSURE TRANSDUCER 2560.0000000 PSIG
CHAMBER PRESSURE 823.8900000 PSIG
CHAMBER PRESSURE 829.7500000 PSIG
IGNITER PRESSURE 858.5800000 PSIG
IGNITER PRESSURE 854.6700000 PSIG
GOX PRESS. EXHAUST FROM THE IGNITER VENTURI 870.3600000 PSIG
GH2 PRESS. EXHAUST FROM THE IGNITER VENTURI 952.7300000 PSIG
H2O PRESS. CALORIMETER EXHAUST PLENUM 757.4200000 PSIG
CALORIMETER CHANNEL 1 INLET PRESSURE 2841.8300000 PSIG
CALORIMETER CHANNEL 2 INLET PRESSURE 2849.3900000 PSIG
CALORIMETER CHANNEL 3 INLET PRESSURE 2812.2000000 PSIG
CALORIMETER CHANNEL 4 INLET PRESSURE 2879.0200000 PSIG
CALORIMETER CHANNEL 5 INLET PRESSURE 2930.6300000 PSIG
CALORIMETER CHANNEL 6 INLET PRESSURE 2728.0000000 PSIG
CALORIMETER CHANNEL 7 INLET PRESSURE 2770.7800000 PSIG
CALORIMETER CHANNEL 8 INLET PRESSURE 2810.3100000 PSIG
CALORIMETER CHANNEL 9 INLET PRESSURE 2798.3200000 PSIG
CALORIMETER CHANNEL 10 INLET PRESSURE 2700.4500000 PSIG
CALORIMETER CHANNEL 11 INLET PRESSURE 2830.9900000 PSIG

LH2 TEMP. UPSTREAM OF THE MAIN FUEL VALVE -376.0000000 DEG F
LH2 TEMP. DOWNSTREAM OF THE MAIN FUEL VALVE -376.0000000 DEG F
LH2 TEMP. INLET TO THE THRUST CHAMBER COOLING JACKET -366.8800000 DEG F
H2 TEMP. EXHAUST FROM THE THRUST CHAMBER COOLING JACKET 88.1700000 DEG F
H2 TEMP. INLET TO THE NOZZLE COOLING JACKET 89.6600000 DEG F
H2 TEMP. EXHAUST FROM THE NOZZLE COOLING JACKET 240.1300000 DEG F
LOX TEMP. INLET TO THE MAIN OXIDIZER VALVE -275.1300000 DEG F
LOX TEMP. EXHAUST FROM THE MAIN OXIDIZER VALVE -275.1300000 DEG F
H2 TEMP. INLET TO THE FUEL MANIFOLD -119.7000000 DEG F
GH2 TEMP. INLET TO THE OLD FUEL MANIFOLD 61.0100000 DEG F
CALORIMETER CHANNEL 11 EXHAUST TEMP. 158.9200000 DEG F
CALORIMETER CHANNEL 12 EXHAUST TEMP. 152.7300000 DEG F

CALORIMETER CHANNEL 13 EXHAUST TEMP. 158.6500000 DEG F
CALORIMETER CHANNEL 14 EXHAUST TEMP. 160.6400000 DEG F
CALORIMETER CHANNEL 15 EXHAUST TEMP. 162.0500000 DEG F
CALORIMETER CHANNEL 16 EXHAUST TEMP. 168.1400000 DEG F
CALORIMETER CHANNEL 17 EXHAUST TEMP. 171.4900000 DEG F
CALORIMETER CHANNEL 18 EXHAUST TEMP. 173.4800000 DEG F
CALORIMETER CHANNEL 19 EXHAUST TEMP. 166.0500000 DEG F
CALORIMETER CHANNEL 20 EXHAUST TEMP. 162.0900000 DEG F
CALORIMETER CHANNEL 21 EXHAUST TEMP. 182.9100000 DEG F
GOX TEMP. INLET TO THE IGNITER VENTURI 47.3900000 DEG F
GH2 TEMP. INLET TO THE IGNITER VENTURI 58.1200000 DEG F
H2O TEMP. CALORIMETER INLET MANIFOLD 64.0000000 DE G F
TEMP. MAIN OXIDIZER VALVE OPERATOR 33.0600000 DEG F
TEMP. MAIN FUEL VALVE OPERATOR 78.5700000 DEG F
H2O TEMP. CALORIMETER EXHAUST PLENUM 88.8100000 DE G F

LOX PRESS. UPSTREAM OF SYSTEM VENTURI 2755.0100000 P SIG
LOX PRESS. DOWNSTREAM OF SYSTEM VENTURI 2718.4600000 PSIG
LH2 PRESS. UPSTREAM OF SYSTEM VENTURI 3453.3000000 P SIG
LH2 PRESS. DOWNSTREAM OF SYSTEM VENTURI 3426.7900000 PSIG

LOX TEMP. UPSTREAM OF THE SYSTEM VENTURI -278.3400000 DEG F
LH2 TEMP. UPSTREAM OF THE SYSTEM VENTURI -380.2100000 DEG F

THE NOZZLE MIXTURE RATIO IS 4.5093410

THE INJECTOR MIXTURE RATIO IS 5.6828940

CORRECTED CALORIMETER CHANNEL 1 INLET PRESS. 2821.6300000 PSIG
CORRECTED CALORIMETER CHANNEL 2 INLET PRESS. 2837.9900000 PSIG
CORRECTED CALORIMETER CHANNEL 3 INLET PRESS. 2794.8000000 PSIG
CORRECTED CALORIMETER CHANNEL 4 INLET PRESS. 2860.8200000 PSIG
CORRECTED CALORIMETER CHANNEL 5 INLET PRESS. 2919.7300000 PSIG
CORRECTED CALORIMETER CHANNEL 6 INLET PRESS. 2721.4000000 PSIG
CORRECTED CALORIMETER CHANNEL 7 INLET PRESS. 2759.9800000 PSIG
CORRECTED CALORIMETER CHANNEL 8 INLET PRESS. 2798.1100000 PSIG
CORRECTED CALORIMETER CHANNEL 9 INLET PRESS. 2784.4200000 PSIG
CORRECTED CALORIMETER CHANNEL 10 INLET PRESS. 2687.6500000 PSIG
CORRECTED CALORIMETER CHANNEL 11 INLET PRESS. 2814.1900000 PSIG

CALORIMETER CHANNEL 1 EXHAUST SATURATION PRESS. 4.6241190 PSIA
CALORIMETER CHANNEL 2 EXHAUST SATURATION PRESS. 3.9804340 PSIA
CALORIMETER CHANNEL 3 EXHAUST SATURATION PRESS. 4.5943150 PSIA
CALORIMETER CHANNEL 4 EXHAUST SATURATION PRESS. 4.8178520 PSIA
CALORIMETER CHANNEL 5 EXHAUST SATURATION PRESS. 4.9817440 PSIA
CALORIMETER CHANNEL 6 EXHAUST SATURATION PRESS. 5.7447460 PSIA
CALORIMETER CHANNEL 7 EXHAUST SATURATION PRESS. 6.2048610 PSIA
CALORIMETER CHANNEL 8 EXHAUST SATURATION PRESS. 6.4925730 PSIA
CALORIMETER CHANNEL 9 EXHAUST SATURATION PRESS. 5.4725160 PSIA
CALORIMETER CHANNEL 10 EXHAUST SATURATION PRESS. 4.9864630 PSIA
CALORIMETER CHANNEL 11 EXHAUST SATURATION PRESS. 8.0130970 PSIA

THE CALORIMETER EXHAUST PLENUM SATURATION PRESSURE .6731969 PSIA

COOLANT PRESSURE DROP ACROSS THRUST CHAMBER 215.4401000 PSID
COOLANT PRESSURE DROP ACROSS NOZZLE 47.8798800 PSID
CALORIMETER CHANNEL 1 PRESSURE DROP 1250.5100000 PSID
CALORIMETER CHANNEL 2 PRESSURE DROP 1340.2900000 PSID
CALORIMETER CHANNEL 3 PRESSURE DROP 1342.2400000 PSID
CALORIMETER CHANNEL 4 PRESSURE DROP 1348.0400000 PSID

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CALORIMETER CHANNEL  5 PRESSURE DROP    1389.1200000 PSID
CALORIMETER CHANNEL  6 PRESSURE DROP    1305.0900000 PSID
CALORIMETER CHANNEL  7 PRESSURE DROP    1275.7700000 PSID
CALORIMETER CHANNEL  8 PRESSURE DROP    1260.6400000 PSID
CALORIMETER CHANNEL  9 PRESSURE DROP    1342.0300000 PSID
CALORIMETER CHANNEL 10 PRESSURE DROP    1265.4000000 PSID
CALORIMETER CHANNEL 11 PRESSURE DROP    1331.4100000 PSID

COOLANT TEMP. RISE THROUGH THE THRUST CHAMBER     455.0500000 DEG F
COOLANT TEMP. RISE THROUGH THE NOZZLE     150.4700000 DEG F
CALORIMETER CHANNEL  1 TEMP. RISE      94.9199800 DEG F
CALORIMETER CHANNEL  2 TEMP. RISE      88.7299800 DEG F
CALORIMETER CHANNEL  3 TEMP. RISE      94.6499600 DEG F
CALORIMETER CHANNEL  4 TEMP. RISE      96.6399500 DEG F
CALORIMETER CHANNEL  5 TEMP. RISE      98.0499900 DEG F
CALORIMETER CHANNEL  6 TEMP. RISE     104.1400000 DEG F
CALORIMETER CHANNEL  7 TEMP. RISE     107.4900000 DEG F
CALORIMETER CHANNEL  8 TEMP. RISE     109.4800000 DEG F
CALORIMETER CHANNEL  9 TEMP. RISE     102.0500000 DEG F
CALORIMETER CHANNEL 10 TEMP. RISE      98.0899700 DEG F
CALORIMETER CHANNEL 11 TEMP. RISE     118.9100000 DEG F

THRUST CHAMBER COOLANT JACKET RESISTANCE     142.9819000 S^2 PER FT^3-IN^2
NOZZLE COOLANT JACKET RESISTANCE         4.2895700 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL  1 RESISTANCE   19748.0100000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL  2 RESISTANCE   20110.5000000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL  3 RESISTANCE   23396.2900000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL  4 RESISTANCE   20514.3600000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL  5 RESISTANCE   22028.0000000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL  6 RESISTANCE   19815.8100000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL  7 RESISTANCE   18247.3100000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL  8 RESISTANCE   17981.0100000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL  9 RESISTANCE   20628.2700000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 10 RESISTANCE   20846.6900000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 11 RESISTANCE   21216.8400000 S^2 PER FT^3-IN^2
MAIN LOX VALVE RESISTANCE        739.7127000 S^2 PER FT^3-IN^2
MAIN FUEL VALVE RESISTANCE       1710.2610000 S^2 PER FT^3-IN^2

HEAT TRANSFER TO THE H2 IN THRUST CHAMBER     3952.3990000 BTU PER S
HEAT TRANSFER TO THE H2 IN NOZZLE     1199.6200000 BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL  1     181.0141000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL  2     172.6438000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL  3     171.3732000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL  4     187.3811000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL  5     186.1367000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL  6     203.0646000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL  7     216.3485000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL  8     220.8685000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL  9     197.4037000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 10     183.3731000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 11     227.2993000BTU PER S

LOX DENSITY UPSTREAM OF MOV       70.1986200 LBM PER FT^3
LH2 DENSITY UPSTREAM OF MFV        4.5093960 LBM PER FT^  3
LH2 DENSITY INLET TO T.C. COOLANT JACKET         3.3611170 LBM PER FT^3
H2 DENSITY EXHAUST FROM T.C. COOLANT JACKET          .4597766 LBM PER FT^3
H2 DENSITY INLET TO NOZZLE COOLANT JACKET          .4537219 LBM PER FT^3
H2 DENSITY EXHAUST FROM NOZZLE COOLANT JACKET          .3475197 LBM PER FT^3
H2O DENSITY CALORIMETER INLET MANIFOLD      63.0242700 LBM PER FT^3
CALORIMETER CHANNEL  1 INLET DENSITY      62.8987500 LBM PER FT^3
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CALORIMETER CHANNEL  2 INLET DENSITY         62.9018600 LBM PER FT^3
CALORIMETER CHANNEL  3 INLET DENSITY         62.8936300 LBM PER FT^3
CALORIMETER CHANNEL  4 INLET DENSITY         62.9062000 LBM PER FT^3
CALORIMETER CHANNEL  5 INLET DENSITY         62.9174400 LBM PER FT^3
CALORIMETER CHANNEL  6 INLET DENSITY         62.8796000 LBM PER FT^3
CALORIMETER CHANNEL  7 INLET DENSITY         62.8869900 LBM PER FT^3
CALORIMETER CHANNEL  8 INLET DENSITY         62.8942500 LBM PER FT^3
CALORIMETER CHANNEL  9 INLET DENSITY         62.8916300 LBM PER FT^3
CALORIMETER CHANNEL 10 INLET DENSITY         62.8731300 LBM PER FT^3
CALORIMETER CHANNEL 11 INLET DENSITY         62.8973000 LBM PER FT^3
CALORIMETER CHANNEL  1 EXHAUST DENSITY         61.3145700 LBM PER FT^3
CALORIMETER CHANNEL  2 EXHAUST DENSITY         61.4213600 LBM PER FT^3
CALORIMETER CHANNEL  3 EXHAUST DENSITY         61.2979400 LBM PER FT^3
CALORIMETER CHANNEL  4 EXHAUST DENSITY         61.2696300 LBM PER FT^3
CALORIMETER CHANNEL  5 EXHAUST DENSITY         61.2448000 LBM PER FT^3
CALORIMETER CHANNEL  6 EXHAUST DENSITY         61.0997000 LBM PER FT^3
CALORIMETER CHANNEL  7 EXHAUST DENSITY         61.0428400 LBM PER FT^3
CALORIMETER CHANNEL  8 EXHAUST DENSITY         61.0110300 LBM PER FT^3
CALORIMETER CHANNEL  9 EXHAUST DENSITY         61.1474600 LBM PER FT^3
CALORIMETER CHANNEL 10 EXHAUST DENSITY         61.2238400 LBM PER FT^3
CALORIMETER CHANNEL 11 EXHAUST DENSITY         60.7978800 LBM PER FT^3

LH2 ENTHALPY INLET TO T.C. COOLANT JACKET        96.0895700 BTU PER LBM
GH2 ENTHALPY EXHAUST FROM T.C. COOLANT JACKET      1852.3800000 BTU PER LBM
GH2 ENTHALPY INLET TO NOZZLE COOLANT JACKET      1857.5230000 BTU PER LBM
GH2 ENTHALPY EXHAUST FROM NOZZLE COOLANT JACKET      2390.5860000 BTU PER LBM
CALORIMETER CHANNEL  1 INLET ENTHALPY        39.9959700 BTU PER LBM
CALORIMETER CHANNEL  2 INLET ENTHALPY        40.0407400 BTU PER LBM
CALORIMETER CHANNEL  3 INLET ENTHALPY        39.9220200 BTU PER LBM
CALORIMETER CHANNEL  4 INLET ENTHALPY        40.1041000 BTU PER LBM
CALORIMETER CHANNEL  5 INLET ENTHALPY        40.2666700 BTU PER LBM
CALORIMETER CHANNEL  6 INLET ENTHALPY        39.7186500 BTU PER LBM
CALORIMETER CHANNEL  7 INLET ENTHALPY        39.8256600 BTU PER LBM
CALORIMETER CHANNEL  8 INLET ENTHALPY        39.9310800 BTU PER LBM
CALORIMETER CHANNEL  9 INLET ENTHALPY        39.8932500 BTU PER LBM
CALORIMETER CHANNEL 10 INLET ENTHALPY        39.6262100 BTU PER LBM
CALORIMETER CHANNEL 11 INLET ENTHALPY        39.9753100 BTU PER LBM
CALORIMETER CHANNEL  1 EXHAUST ENTHALPY        130.6964000 BTU PER LBM
CALORIMETER CHANNEL  2 EXHAUST ENTHALPY        124.3608000 BTU PER LBM
CALORIMETER CHANNEL  3 EXHAUST ENTHALPY        130.1410000 BTU PER LBM
CALORIMETER CHANNEL  4 EXHAUST ENTHALPY        132.2671000 BTU PER LBM
CALORIMETER CHANNEL  5 EXHAUST ENTHALPY        133.7134000 BTU PER LBM
CALORIMETER CHANNEL  6 EXHAUST ENTHALPY        139.5036000 BTU PER LBM
CALORIMETER CHANNEL  7 EXHAUST ENTHALPY        143.0035000 BTU PER LBM
CALORIMETER CHANNEL  8 EXHAUST ENTHALPY        145.1127000 BTU PER LBM
CALORIMETER CHANNEL  9 EXHAUST ENTHALPY        137.4841000 BTU PER LBM
CALORIMETER CHANNEL 10 EXHAUST ENTHALPY        133.4921000 BTU PER LBM
CALORIMETER CHANNEL 11 EXHAUST ENTHALPY        154.3860000 BTU PER LBM

GOX VENTURI FLOW          .0543122 LBM PER S
GH2 VENTURI FLOW          .0550558 LBM PER S
LOX INJECTOR FLOW       13.0474900 LBM PER S
GH2 INJECTOR FLOW        2.2504250 LBM PER S
CALORIMETER CHANNEL  1 H2O FLOW        1.9957360 LBM PER S
CALORIMETER CHANNEL  2 H2O FLOW        2.0474800 LBM PER S
CALORIMETER CHANNEL  3 H2O FLOW        1.8995240 LBM PER S
CALORIMETER CHANNEL  4 H2O FLOW        2.0331490 LBM PER S
CALORIMETER CHANNEL  5 H2O FLOW        1.9919020 LBM PER S
CALORIMETER CHANNEL  6 H2O FLOW        2.0350220 LBM PER S
CALORIMETER CHANNEL  7 H2O FLOW        2.0968490 LBM PER S
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CALORIMETER CHANNEL  8 H2O FLOW       2.0998780 LBM PER S
CALORIMETER CHANNEL  9 H2O FLOW       2.0227690 LBM PER S
CALORIMETER CHANNEL 10 H2O FLOW       1.9535650 LBM PER S
CALORIMETER CHANNEL 11 H2O FLOW       1.9866970 LBM PER S

THE THEORETICAL CSTAR    8109.0230000
THE CSTAR     8051.3790000
CSTAR EFFICIENCY      99.2891400
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T = 219.0, MR:5.0 (VS. 4.7 ACTUAL)

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LH2 PRESS. UPSTREAM OF THE MAIN FUEL VALVE    3449.7100000 PSIG
LH2 PRESS. DOWNSTREAM OF THE MAIN FUEL VALVE    1624.9700000 PSIG
LH2 PRESS. INLET TO THE THRUST CHAMBER COOLANT JACKET    1729.0700000 PSIG
H2 PRESS. EXHAUST FROM THE THRUST CHAMBER COOLING JACKET    1502.4000000 PSIG
H2 PRESS. INLET TO THE NOZZLE COOLING JACKET    1485.8100000 PSIG
H2 PRESS. EXHAUST FROM THE NOZZLE COOLING JACKET    1433.3100000 PSIG
H2 PRESS. EXHAUST FROM THE NOZZLE COOLING JACKET-REDUNDANT  1433.3100000PSIG
NO PRESSURE AT P8
H2 PRESS. INLET TO THE FUEL MANIFOLD    955.9200000 PSIG
GH2 PRESS. INLET TO THE OLD FUEL MANIFOLD    1426.4400000 PSIG
CALORIMETER CHANNEL 11 EXHAUST PRESSURE    1581.2400000 PSIG
CALORIMETER CHANNEL 12 EXHAUST PRESSURE    1500.6800000 PSIG
CALORIMETER CHANNEL 13 EXHAUST PRESSURE    1453.8600000 PSIG
CALORIMETER CHANNEL 14 EXHAUST PRESSURE    1512.2600000 PSIG
CALORIMETER CHANNEL 15 EXHAUST PRESSURE    1532.3200000 PSIG
CALORIMETER CHANNEL 16 EXHAUST PRESSURE    1416.7600000 PSIG
CALORIMETER CHANNEL 17 EXHAUST PRESSURE    1484.5200000 PSIG
CALORIMETER CHANNEL 18 EXHAUST PRESSURE    1536.0300000 PSIG
CALORIMETER CHANNEL 19 EXHAUST PRESSURE    1435.9900000 PSIG
CALORIMETER CHANNEL 20 EXHAUST PRESSURE    1417.6900000 PSIG
CALORIMETER CHANNEL 21 EXHAUST PRESSURE    1480.4200000 PSIG
LOX PRESS. INLET TO THE MAIN OXIDIZER VALVE    2729.9300000 PSIG
LOX PRESS. EXHAUST FROM THE MAIN OXIDIZER VALVE    884.9800000 PSIG
H2O PRESS. CALORIMETER INLET MANIFOLD    3484.8600000 PSIG
GOX PRESS. INLET TO THE IGNITER VENTURI    2149.3100000 PSIG
NO PRESSURE AT P26
GH2 PRESS. INLET TO THE IGNITER VENTURI    1992.3000000 PSIG
NO PRESSURE AT P28
LOX DOME HIGH FREQUENCY PRESSURE TRANSDUCER    2560.0000000 PSIG
CHAMBER PRESSURE    800.6900000 PSIG
CHAMBER PRESSURE    806.2200000 PSIG
IGNITER PRESSURE    834.3500000 PSIG
IGNITER PRESSURE    830.8900000 PSIG
GOX PRESS. EXHAUST FROM THE IGNITER VENTURI    846.5500000 PSIG
GH2 PRESS. EXHAUST FROM THE IGNITER VENTURI    931.4700000 PSIG
H2O PRESS. CALORIMETER EXHAUST PLENUM    756.4700000 PSIG
CALORIMETER CHANNEL  1 INLET PRESSURE    2878.2500000 PSIG
CALORIMETER CHANNEL  2 INLET PRESSURE    2862.4600000 PSIG
CALORIMETER CHANNEL  3 INLET PRESSURE    2841.1700000 PSIG
CALORIMETER CHANNEL  4 INLET PRESSURE    2870.9200000 PSIG
CALORIMETER CHANNEL  5 INLET PRESSURE    2933.3200000 PSIG
CALORIMETER CHANNEL  6 INLET PRESSURE    2712.0800000 PSIG
CALORIMETER CHANNEL  7 INLET PRESSURE    2770.0400000 PSIG
CALORIMETER CHANNEL  8 INLET PRESSURE    2807.2700000 PSIG
CALORIMETER CHANNEL  9 INLET PRESSURE    2775.1000000 PSIG
CALORIMETER CHANNEL 10 INLET PRESSURE    2683.6900000 PSIG
CALORIMETER CHANNEL 11 INLET PRESSURE    2815.4300000 PSIG

LH2 TEMP. UPSTREAM OF THE MAIN FUEL VALVE    -381.0000000 DEG F
LH2 TEMP. DOWNSTREAM OF THE MAIN FUEL VALVE    -381.0000000 DEG F
LH2 TEMP. INLET TO THE THRUST CHAMBER COOLING JACKET    -367.2500000 DEG F
H2 TEMP. EXHAUST FROM THE THRUST CHAMBER COOLING JACKET    29.6600000 DEG F
H2 TEMP. INLET TO THE NOZZLE COOLING JACKET    31.3100000 DEG F
H2 TEMP. EXHAUST FROM THE NOZZLE COOLING JACKET    206.2000000 DEG F
LOX TEMP. INLET TO THE MAIN OXIDIZER VALVE    -275.2200000 DEG F
LOX TEMP. EXHAUST FROM THE MAIN OXIDIZER VALVE    -275.2200000 DEG F
H2 TEMP. INLET TO THE FUEL MANIFOLD    -80.6600000 DEG F
GH2 TEMP. INLET TO THE OLD FUEL MANIFOLD    61.6300000 DEG F
CALORIMETER CHANNEL 11 EXHAUST TEMP.    150.0400000 DEG F
CALORIMETER CHANNEL 12 EXHAUST TEMP.    148.0800000 DEG F
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CALORIMETER CHANNEL 13 EXHAUST TEMP. 154.3700000 DEG F
CALORIMETER CHANNEL 14 EXHAUST TEMP. 156.1400000 DEG F
CALORIMETER CHANNEL 15 EXHAUST TEMP. 157.7300000 DEG F
CALORIMETER CHANNEL 16 EXHAUST TEMP. 163.6700000 DEG F
CALORIMETER CHANNEL 17 EXHAUST TEMP. 167.1700000 DEG F
CALORIMETER CHANNEL 18 EXHAUST TEMP. 170.4900000 DEG F
CALORIMETER CHANNEL 19 EXHAUST TEMP. 166.1000000 DEG F
CALORIMETER CHANNEL 20 EXHAUST TEMP. 164.3800000 DEG F
CALORIMETER CHANNEL 21 EXHAUST TEMP. 186.4300000 DEG F
GOX TEMP. INLET TO THE IGNITER VENTURI 48.0700000 DEG F
GH2 TEMP. INLET TO THE IGNITER VENTURI 58.2800000 DEG F
H2O TEMP. CALORIMETER INLET MANIFOLD 63.5000000 DE G F
TEMP. MAIN OXIDIZER VALVE OPERATOR 33.1900000 DEG F
TEMP. MAIN FUEL VALVE OPERATOR 77.8600000 DEG F
H2O TEMP. CALORIMETER EXHAUST PLENUM 88.8700000 DE G F

LOX PRESS. UPSTREAM OF SYSTEM VENTURI 2761.1900000 P SIG
LOX PRESS. DOWNSTREAM OF SYSTEM VENTURI 2730.1900000 PSIG
LH2 PRESS. UPSTREAM OF SYSTEM VENTURI 3450.1600000 P SIG
LH2 PRESS. DOWNSTREAM OF SYSTEM VENTURI 3417.6300000 PSIG

LOX TEMP. UPSTREAM OF THE SYSTEM VENTURI -278.4400000 DEG F
LH2 TEMP. UPSTREAM OF THE SYSTEM VENTURI -380.0400000 DEG F

THE NOZZLE MIXTURE RATIO IS 3.8005770

THE INJECTOR MIXTURE RATIO IS 4.6856760

CORRECTED CALORIMETER CHANNEL 1 INLET PRESS. 2858.0500000 PSIG
CORRECTED CALORIMETER CHANNEL 2 INLET PRESS. 2851.0600000 PSIG
CORRECTED CALORIMETER CHANNEL 3 INLET PRESS. 2823.7700000 PSIG
CORRECTED CALORIMETER CHANNEL 4 INLET PRESS. 2852.7200000 PSIG
CORRECTED CALORIMETER CHANNEL 5 INLET PRESS. 2922.4200000 PSIG
CORRECTED CALORIMETER CHANNEL 6 INLET PRESS. 2705.4800000 PSIG
CORRECTED CALORIMETER CHANNEL 7 INLET PRESS. 2759.2400000 PSIG
CORRECTED CALORIMETER CHANNEL 8 INLET PRESS. 2795.0700000 PSIG
CORRECTED CALORIMETER CHANNEL 9 INLET PRESS. 2761.2000000 PSIG
CORRECTED CALORIMETER CHANNEL 10 INLET PRESS. 2670.8900000 PSIG
CORRECTED CALORIMETER CHANNEL 11 INLET PRESS. 2798.6300000 PSIG

CALORIMETER CHANNEL 1 EXHAUST SATURATION PRESS. 3.7253510 PSIA
CALORIMETER CHANNEL 2 EXHAUST SATURATION PRESS. 3.5483390 PSIA
CALORIMETER CHANNEL 3 EXHAUST SATURATION PRESS. 4.1430880 PSIA
CALORIMETER CHANNEL 4 EXHAUST SATURATION PRESS. 4.3249160 PSIA
CALORIMETER CHANNEL 5 EXHAUST SATURATION PRESS. 4.4939740 PSIA
CALORIMETER CHANNEL 6 EXHAUST SATURATION PRESS. 5.1758290 PSIA
CALORIMETER CHANNEL 7 EXHAUST SATURATION PRESS. 5.6170180 PSIA
CALORIMETER CHANNEL 8 EXHAUST SATURATION PRESS. 6.0643810 PSIA
CALORIMETER CHANNEL 9 EXHAUST SATURATION PRESS. 5.4788980 PSIA
CALORIMETER CHANNEL 10 EXHAUST SATURATION PRESS. 5.2628860 PSIA
CALORIMETER CHANNEL 11 EXHAUST SATURATION PRESS. 8.6522320 PSIA

THE CALORIMETER EXHAUST PLENUM SATURATION PRESSURE .6744722 PSIA

COOLANT PRESSURE DROP ACROSS THRUST CHAMBER 226.6699000 PSID
COOLANT PRESSURE DROP ACROSS NOZZLE 52.5000000 PSID
CALORIMETER CHANNEL 1 PRESSURE DROP 1276.8100000 PSID
CALORIMETER CHANNEL 2 PRESSURE DROP 1350.3800000 PSID
CALORIMETER CHANNEL 3 PRESSURE DROP 1369.9100000 PSID
CALORIMETER CHANNEL 4 PRESSURE DROP 1340.4600000 PSID

CALORIMETER CHANNEL 5 PRESSURE DROP   1390.1000000 PSID
CALORIMETER CHANNEL 6 PRESSURE DROP   1288.7200000 PSID
CALORIMETER CHANNEL 7 PRESSURE DROP   1274.7200000 PSID
CALORIMETER CHANNEL 8 PRESSURE DROP   1259.0400000 PSID
CALORIMETER CHANNEL 9 PRESSURE DROP   1325.2100000 PSID
CALORIMETER CHANNEL 10 PRESSURE DROP   1253.2000000 PSID
CALORIMETER CHANNEL 11 PRESSURE DROP   1318.2100000 PSID

COOLANT TEMP. RISE THROUGH THE THRUST CHAMBER   396.9100000 DEG F
COOLANT TEMP. RISE THROUGH THE NOZZLE   174.8900000 DEG F
CALORIMETER CHANNEL 1 TEMP. RISE   86.5399800 DEG F
CALORIMETER CHANNEL 2 TEMP. RISE   84.5799600 DEG F
CALORIMETER CHANNEL 3 TEMP. RISE   90.8700000 DEG F
CALORIMETER CHANNEL 4 TEMP. RISE   92.6399500 DEG F
CALORIMETER CHANNEL 5 TEMP. RISE   94.2299800 DEG F
CALORIMETER CHANNEL 6 TEMP. RISE   100.1700000 DEG F
CALORIMETER CHANNEL 7 TEMP. RISE   103.6700000 DEG F
CALORIMETER CHANNEL 8 TEMP. RISE   106.9900000 DEG F
CALORIMETER CHANNEL 9 TEMP. RISE   102.6000000 DEG F
CALORIMETER CHANNEL 10 TEMP. RISE   100.8800000 DEG F
CALORIMETER CHANNEL 11 TEMP. RISE   122.9299000 DEG F

THRUST CHAMBER COOLANT JACKET RESISTANCE   123.4389000 S^2 PER FT^3-IN^2
NOZZLE COOLANT JACKET RESISTANCE   4.4437530 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 1 RESISTANCE   21336.9100000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 2 RESISTANCE   20649.6600000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 3 RESISTANCE   24911.5600000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 4 RESISTANCE   20090.0500000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 5 RESISTANCE   22103.9400000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 6 RESISTANCE   19133.2400000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 7 RESISTANCE   18183.1700000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 8 RESISTANCE   17846.0700000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 9 RESISTANCE   19667.9600000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 10 RESISTANCE   20182.2500000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 11 RESISTANCE   20480.1000000 S^2 PER FT^3-IN^2
MAIN LOX VALVE RESISTANCE   896.9855000 S^2 PER FT^3-IN^2
MAIN FUEL VALVE RESISTANCE   1324.0850000 S^2 PER FT^3-IN^2

HEAT TRANSFER TO THE H2 IN THRUST CHAMBER   3897.7560000 BTU PER S
HEAT TRANSFER TO THE H2 IN NOZZLE   1578.6340000 BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 1   159.6562000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 2   162.5850000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 3   160.6486000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 4   180.6995000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 5   178.3092000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 6   197.2996000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 7   208.6527000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 8   216.3401000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 9   202.1129000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 10   191.0190000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 11   238.3370000BTU PER S

LOX DENSITY UPSTREAM OF MOV   70.2234300 LBM PER FT^3
LH2 DENSITY UPSTREAM OF MFV   4.6132200 LBM PER FT^ 3
LH2 DENSITY INLET TO T.C. COOLANT JACKET   3.4621640 LBM PER FT^3
H2 DENSITY EXHAUST FROM T.C. COOLANT JACKET   .5454462 LBM PER FT^3
H2 DENSITY INLET TO NOZZLE COOLANT JACKET   .5381212 LBM PER FT^3
H2 DENSITY EXHAUST FROM NOZZLE COOLANT JACKET   .3880433 LBM PER FT^3
H2O DENSITY CALORIMETER INLET MANIFOLD   63.0282800 LBM PER FT^3
CALORIMETER CHANNEL 1 INLET DENSITY   62.9093300 LBM PER FT^3

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CALORIMETER CHANNEL  2 INLET DENSITY         62.9079900 LBM PER FT^3
CALORIMETER CHANNEL  3 INLET DENSITY         62.9028100 LBM PER FT^3
CALORIMETER CHANNEL  4 INLET DENSITY         62.9083200 LBM PER FT^3
CALORIMETER CHANNEL  5 INLET DENSITY         62.9215900 LBM PER FT^3
CALORIMETER CHANNEL  6 INLET DENSITY         62.8802200 LBM PER FT^3
CALORIMETER CHANNEL  7 INLET DENSITY         62.8904900 LBM PER FT^3
CALORIMETER CHANNEL  8 INLET DENSITY         62.8973200 LBM PER FT^3
CALORIMETER CHANNEL  9 INLET DENSITY         62.8908700 LBM PER FT^3
CALORIMETER CHANNEL 10 INLET DENSITY         62.8735600 LBM PER FT^3
CALORIMETER CHANNEL 11 INLET DENSITY         62.8980000 LBM PER FT^3
CALORIMETER CHANNEL  1 EXHAUST DENSITY         61.4879100 LBM PER FT^3
CALORIMETER CHANNEL  2 EXHAUST DENSITY         61.5098800 LBM PER FT^3
CALORIMETER CHANNEL  3 EXHAUST DENSITY         61.3816900 LBM PER FT^3
CALORIMETER CHANNEL  4 EXHAUST DENSITY         61.3581700 LBM PER FT^3
CALORIMETER CHANNEL  5 EXHAUST DENSITY         61.3308100 LBM PER FT^3
CALORIMETER CHANNEL  6 EXHAUST DENSITY         61.1909900 LBM PER FT^3
CALORIMETER CHANNEL  7 EXHAUST DENSITY         61.1323700 LBM PER FT^3
CALORIMETER CHANNEL  8 EXHAUST DENSITY         61.0734400 LBM PER FT^3
CALORIMETER CHANNEL  9 EXHAUST DENSITY         61.1452100 LBM PER FT^3
CALORIMETER CHANNEL 10 EXHAUST DENSITY         61.1768100 LBM PER FT^3
CALORIMETER CHANNEL 11 EXHAUST DENSITY         60.7197100 LBM PER FT^3

LH2 ENTHALPY INLET TO T.C. COOLANT JACKET        95.4698000 BTU PER LBM
GH2 ENTHALPY EXHAUST FROM T.C. COOLANT JACKET     1641.3290000 BTU PER LBM
GH2 ENTHALPY INLET TO NOZZLE COOLANT JACKET      1647.1680000 BTU PER LBM
GH2 ENTHALPY EXHAUST FROM NOZZLE COOLANT JACKET     2273.2580000 BTU PER LBM
CALORIMETER CHANNEL  1 INLET ENTHALPY         39.6031700 BTU PER LBM
CALORIMETER CHANNEL  2 INLET ENTHALPY         39.5846500 BTU PER LBM
CALORIMETER CHANNEL  3 INLET ENTHALPY         39.5086100 BTU PER LBM
CALORIMETER CHANNEL  4 INLET ENTHALPY         39.5884700 BTU PER LBM
CALORIMETER CHANNEL  5 INLET ENTHALPY         39.7819300 BTU PER LBM
CALORIMETER CHANNEL  6 INLET ENTHALPY         39.1820300 BTU PER LBM
CALORIMETER CHANNEL  7 INLET ENTHALPY         39.3298900 BTU PER LBM
CALORIMETER CHANNEL  8 INLET ENTHALPY         39.4297200 BTU PER LBM
CALORIMETER CHANNEL  9 INLET ENTHALPY         39.3354600 BTU PER LBM
CALORIMETER CHANNEL 10 INLET ENTHALPY         39.0862500 BTU PER LBM
CALORIMETER CHANNEL 11 INLET ENTHALPY         39.4395100 BTU PER LBM
CALORIMETER CHANNEL  1 EXHAUST ENTHALPY         121.8901000 BTU PER LBM
CALORIMETER CHANNEL  2 EXHAUST ENTHALPY         119.7444000 BTU PER LBM
CALORIMETER CHANNEL  3 EXHAUST ENTHALPY         125.8852000 BTU PER LBM
CALORIMETER CHANNEL  4 EXHAUST ENTHALPY         127.7880000 BTU PER LBM
CALORIMETER CHANNEL  5 EXHAUST ENTHALPY         129.4186000 BTU PER LBM
CALORIMETER CHANNEL  6 EXHAUST ENTHALPY         135.0523000 BTU PER LBM
CALORIMETER CHANNEL  7 EXHAUST ENTHALPY         138.7007000 BTU PER LBM
CALORIMETER CHANNEL  8 EXHAUST ENTHALPY         142.1302000 BTU PER LBM
CALORIMETER CHANNEL  9 EXHAUST ENTHALPY         137.5188000 BTU PER LBM
CALORIMETER CHANNEL 10 EXHAUST ENTHALPY         135.7619000 BTU PER LBM
CALORIMETER CHANNEL 11 EXHAUST ENTHALPY         157.8927000 BTU PER LBM

GOX VENTURI FLOW          .0538188 LBM PER S
GH2 VENTURI FLOW          .0549562 LBM PER S
LOX INJECTOR FLOW       12.0182300 LBM PER S
GH2 INJECTOR FLOW        2.5214170 LBM PER S
CALORIMETER CHANNEL  1 H2O FLOW       1.9402380 LBM PER S
CALORIMETER CHANNEL  2 H2O FLOW       2.0282640 LBM PER S
CALORIMETER CHANNEL  3 H2O FLOW       1.8598620 LBM PER S
CALORIMETER CHANNEL  4 H2O FLOW       2.0487570 LBM PER S
CALORIMETER CHANNEL  5 H2O FLOW       1.9892440 LBM PER S
CALORIMETER CHANNEL  6 H2O FLOW       2.0579840 LBM PER S
CALORIMETER CHANNEL  7 H2O FLOW       2.0997380 LBM PER S
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CALORIMETER CHANNEL  8 H2O FLOW        2.1065150 LBM PER S
CALORIMETER CHANNEL  9 H2O FLOW        2.0585270 LBM PER S
CALORIMETER CHANNEL 10 H2O FLOW        1.9758750 LBM PER S
CALORIMETER CHANNEL 11 H2O FLOW        2.0120770 LBM PER S

THE THEORETICAL CSTAR    8266.8000000
THE CSTAR    8215.3280000
CSTAR EFFICIENCY       99.3773700
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Test 017 - 041: Smooth Wall Combustor
Reduced Data Time Slices

Time Slice: (Sec.)	171.5	173.0	176.0	181.0
MR (Predicted	6.0	6.5	7.0	5.0
MR (Actual)	5.6	5.8	6.1	5.7

T = 171.5, MR:6.0 (VS. 5.6 ACTUAL)

LH2 PRESS. UPSTREAM OF THE MAIN FUEL VALVE 3750.3000000 PSIG
LH2 PRESS. DOWNSTREAM OF THE MAIN FUEL VALVE 1500.9800000 PSIG
LH2 PRESS. INLET TO THE THRUST CHAMBER COOLANT JACKET 1587.0600000 PSIG
H2 PRESS. EXHAUST FROM THE THRUST CHAMBER COOLING JACKET 1377.2900000 PSIG
PRESS. INLET TO THE NOZZLE COOLING JACKET 1363.3300000 PSIG
H2 PRESS. EXHAUST FROM THE NOZZLE COOLING JACKET 1334.5700000 PSIG
H2 PRESS. EXHAUST FROM THE NOZZLE COOLING JACKET-REDUNDANT 1334.5700000PSIG
NO PRESSURE AT P8
H2 PRESS. INLET TO THE FUEL MANIFOLD 973.5400000 PSIG
GH2 PRESS. INLET TO THE OLD FUEL MANIFOLD 929.0000000 PSIG
CALORIMETER CHANNEL 11 EXHAUST PRESSURE 1576.2600000 PSIG
CALORIMETER CHANNEL 12 EXHAUST PRESSURE 1490.7000000 PSIG
CALORIMETER CHANNEL 13 EXHAUST PRESSURE 1475.8300000 PSIG
CALORIMETER CHANNEL 14 EXHAUST PRESSURE 1544.0200000 PSIG
CALORIMETER CHANNEL 15 EXHAUST PRESSURE 1549.2200000 PSIG
CALORIMETER CHANNEL 16 EXHAUST PRESSURE 1413.2600000 PSIG
CALORIMETER CHANNEL 17 EXHAUST PRESSURE 1489.9700000 PSIG
CALORIMETER CHANNEL 18 EXHAUST PRESSURE 1555.8600000 PSIG
CALORIMETER CHANNEL 19 EXHAUST PRESSURE 1460.3300000 PSIG
CALORIMETER CHANNEL 20 EXHAUST PRESSURE 1433.9900000 PSIG
CALORIMETER CHANNEL 21 EXHAUST PRESSURE 1467.0100000 PSIG
LOX PRESS. INLET TO THE MAIN OXIDIZER VALVE 2737.5700000 PSIG
LOX PRESS. EXHAUST FROM THE MAIN OXIDIZER VALVE 937.4400000 PSIG
H2O PRESS. CALORIMETER INLET MANIFOLD 3477.9800000 PSIG
GOX PRESS. INLET TO THE IGNITER VENTURI 2028.5700000 PSIG
NO PRESSURE AT P26
GH2 PRESS. INLET TO THE IGNITER VENTURI 1965.3700000 PSIG
NO PRESSURE AT P28
LOX DOME HIGH FREQUENCY PRESSURE TRANSDUCER 2560.0000000 PSIG
CHAMBER PRESSURE 855.0700000 PSIG
CHAMBER PRESSURE 857.5900000 PSIG
IGNITER PRESSURE 891.8400000 PSIG
NITER PRESSURE 888.6700000 PSIG
X PRESS. EXHAUST FROM THE IGNITER VENTURI 888.3300000 PSIG
GH2 PRESS. EXHAUST FROM THE IGNITER VENTURI 991.6100000 PSIG
H2O PRESS. CALORIMETER EXHAUST PLENUM 759.9000000 PSIG
CALORIMETER CHANNEL 1 INLET PRESSURE 2844.7800000 PSIG
CALORIMETER CHANNEL 2 INLET PRESSURE 2805.8100000 PSIG
CALORIMETER CHANNEL 3 INLET PRESSURE 2793.8200000 PSIG
CALORIMETER CHANNEL 4 INLET PRESSURE 2762.5900000 PSIG
CALORIMETER CHANNEL 5 INLET PRESSURE 2935.8700000 PSIG
CALORIMETER CHANNEL 6 INLET PRESSURE 2737.8300000 PSIG
CALORIMETER CHANNEL 7 INLET PRESSURE 2779.3400000 PSIG
CALORIMETER CHANNEL 8 INLET PRESSURE 2819.5900000 PSIG
CALORIMETER CHANNEL 9 INLET PRESSURE 2865.7800000 PSIG
CALORIMETER CHANNEL 10 INLET PRESSURE 2721.0700000 PSIG
CALORIMETER CHANNEL 11 INLET PRESSURE 2754.0600000 PSIG

LH2 TEMP. UPSTREAM OF THE MAIN FUEL VALVE -390.0000000 DEG F
LH2 TEMP. DOWNSTREAM OF THE MAIN FUEL VALVE -390.0000000 DEG F
LH2 TEMP. INLET TO THE THRUST CHAMBER COOLING JACKET -367.1900000 DEG F
H2 TEMP. EXHAUST FROM THE THRUST CHAMBER COOLING JACKET -62.1300000 DEG F
H2 TEMP. INLET TO THE NOZZLE COOLING JACKET -57.2300000 DEG F
H2 TEMP. EXHAUST FROM THE NOZZLE COOLING JACKET 48.0200000 DEG F
LOX TEMP. INLET TO THE MAIN OXIDIZER VALVE -274.0500000 DEG F
LOX TEMP. EXHAUST FROM THE MAIN OXIDIZER VALVE -274.0500000 DEG F
H2 TEMP. INLET TO THE FUEL MANIFOLD 48.1200000 DEG F
GH2 TEMP. INLET TO THE OLD FUEL MANIFOLD 77.5500000 DEG F
CALORIMETER CHANNEL 11 EXHAUST TEMP. 128.1100000 DEG F
CALORIMETER CHANNEL 12 EXHAUST TEMP. 132.0100000 DEG F
LORIMETER CHANNEL 13 EXHAUST TEMP. 133.2600000 DEG F
LORIMETER CHANNEL 14 EXHAUST TEMP. 135.1100000 DEG F
CALORIMETER CHANNEL 15 EXHAUST TEMP. 136.2800000 DEG F
CALORIMETER CHANNEL 16 EXHAUST TEMP. 139.9700000 DEG F
CALORIMETER CHANNEL 17 EXHAUST TEMP. 141.1000000 DEG F
CALORIMETER CHANNEL 18 EXHAUST TEMP. 139.3400000 DEG F

CALORIMETER CHANNEL 19 EXHAUST TEMP.	127.8100000 DEG F
CALORIMETER CHANNEL 20 EXHAUST TEMP.	122.3400000 DEG F
CALORIMETER CHANNEL 21 EXHAUST TEMP.	129.0000000 DEG F
OX TEMP. INLET TO THE IGNITER VENTURI	59.8300000 DEG F
2 TEMP. INLET TO THE IGNITER VENTURI	75.7600000 DEG F
H2O TEMP. CALORIMETER INLET MANIFOLD	65.5700000 DEG F
TEMP. MAIN OXIDIZER VALVE OPERATOR	34.8700000 DEG F
TEMP. MAIN FUEL VALVE OPERATOR	84.3000000 DEG F
H2O TEMP. CALORIMETER EXHAUST PLENUM	95.6400000 DEG F

LOX PRESS. UPSTREAM OF SYSTEM VENTURI	2773.0000000 PSIG
LOX PRESS. DOWNSTREAM OF SYSTEM VENTURI	2732.8600000 PSIG
LH2 PRESS. UPSTREAM OF SYSTEM VENTURI	3754.7000000 PSIG
LH2 PRESS. DOWNSTREAM OF SYSTEM VENTURI	3727.2400000 PSIG

LOX TEMP. UPSTREAM OF THE SYSTEM VENTURI	-279.3300000 DEG F
LH2 TEMP. UPSTREAM OF THE SYSTEM VENTURI	-382.0200000 DEG F

THE NOZZLE MIXTURE RATIO IS 4.5159040

THE INJECTOR MIXTURE RATIO IS 5.6283470

CORRECTED CALORIMETER CHANNEL 1 INLET PRESS.	2824.5800000 PSIG
CORRECTED CALORIMETER CHANNEL 2 INLET PRESS.	2794.4100000 PSIG
CORRECTED CALORIMETER CHANNEL 3 INLET PRESS.	2776.4200000 PSIG
CORRECTED CALORIMETER CHANNEL 4 INLET PRESS.	2744.3900000 PSIG
CORRECTED CALORIMETER CHANNEL 5 INLET PRESS.	2924.9700000 PSIG
CORRECTED CALORIMETER CHANNEL 6 INLET PRESS.	2731.2300000 PSIG
CORRECTED CALORIMETER CHANNEL 7 INLET PRESS.	2768.5400000 PSIG
CORRECTED CALORIMETER CHANNEL 8 INLET PRESS.	2807.3900000 PSIG
CORRECTED CALORIMETER CHANNEL 9 INLET PRESS.	2851.8800000 PSIG
CORRECTED CALORIMETER CHANNEL 10 INLET PRESS.	2708.2700000 PSIG
CORRECTED CALORIMETER CHANNEL 11 INLET PRESS.	2737.2600000 PSIG

CALORIMETER CHANNEL 1 EXHAUST SATURATION PRESS.	2.1153310 PSIA
CALORIMETER CHANNEL 2 EXHAUST SATURATION PRESS.	2.3475600 PSIA
CALORIMETER CHANNEL 3 EXHAUST SATURATION PRESS.	2.4264520 PSIA
CALORIMETER CHANNEL 4 EXHAUST SATURATION PRESS.	2.5473670 PSIA
CALORIMETER CHANNEL 5 EXHAUST SATURATION PRESS.	2.6264570 PSIA
CALORIMETER CHANNEL 6 EXHAUST SATURATION PRESS.	2.8897580 PSIA
CALORIMETER CHANNEL 7 EXHAUST SATURATION PRESS.	2.9747510 PSIA
CALORIMETER CHANNEL 8 EXHAUST SATURATION PRESS.	2.8432770 PSIA
CALORIMETER CHANNEL 9 EXHAUST SATURATION PRESS.	2.0983080 PSIA
CALORIMETER CHANNEL 10 EXHAUST SATURATION PRESS.	1.8078920 PSIA
CALORIMETER CHANNEL 11 EXHAUST SATURATION PRESS.	2.1665190 PSIA

THE CALORIMETER EXHAUST PLENUM SATURATION PRESSURE .8324181 PSIA

COOLANT PRESSURE DROP ACROSS THRUST CHAMBER	209.7700000 PSID
COOLANT PRESSURE DROP ACROSS NOZZLE	28.7600100 PSID
CALORIMETER CHANNEL 1 PRESSURE DROP	1248.3200000 PSID
CALORIMETER CHANNEL 2 PRESSURE DROP	1303.7100000 PSID
CALORIMETER CHANNEL 3 PRESSURE DROP	1300.5900000 PSID
CALORIMETER CHANNEL 4 PRESSURE DROP	1200.3700000 PSID
CALORIMETER CHANNEL 5 PRESSURE DROP	1375.7500000 PSID
CALORIMETER CHANNEL 6 PRESSURE DROP	1317.9700000 PSID
CALORIMETER CHANNEL 7 PRESSURE DROP	1278.5700000 PSID
CALORIMETER CHANNEL 8 PRESSURE DROP	1251.5300000 PSID
CALORIMETER CHANNEL 9 PRESSURE DROP	1391.5500000 PSID
CALORIMETER CHANNEL 10 PRESSURE DROP	1274.2800000 PSID
CALORIMETER CHANNEL 11 PRESSURE DROP	1270.2500000 PSID

COOLANT TEMP. RISE THROUGH THE THRUST CHAMBER	305.0600000 DEG F
COOLANT TEMP. RISE THROUGH THE NOZZLE	105.2500000 DEG F
CALORIMETER CHANNEL 1 TEMP. RISE	62.5400400 DEG F
CALORIMETER CHANNEL 2 TEMP. RISE	66.4400000 DEG F

CALORIMETER CHANNEL 3 TEMP. RISE 67.6900000 DEG F
CALORIMETER CHANNEL 4 TEMP. RISE 69.5400400 DEG F
CALORIMETER CHANNEL 5 TEMP. RISE 70.7100200 DEG F
CALORIMETER CHANNEL 6 TEMP. RISE 74.4000200 DEG F
CALORIMETER CHANNEL 7 TEMP. RISE 75.5300300 DEG F
CALORIMETER CHANNEL 8 TEMP. RISE 73.7700200 DEG F
CALORIMETER CHANNEL 9 TEMP. RISE 62.2399900 DEG F
CALORIMETER CHANNEL 10 TEMP. RISE 56.7700200 DEG F
CALORIMETER CHANNEL 11 TEMP. RISE 63.4300500 DEG F

THRUST CHAMBER COOLANT JACKET RESISTANCE 123.5327000 S^2 PER FT^3-IN^2
NOZZLE COOLANT JACKET RESISTANCE 3.0525080 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 1 RESISTANCE 19983.3700000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 2 RESISTANCE 18457.2400000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 3 RESISTANCE 22249.4400000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 4 RESISTANCE 15434.6300000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 5 RESISTANCE 22257.1100000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 6 RESISTANCE 20432.3800000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 7 RESISTANCE 18661.5600000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 8 RESISTANCE 18258.1700000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 9 RESISTANCE 23951.0000000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 10 RESISTANCE 21724.8900000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 11 RESISTANCE 18246.6900000 S^2 PER FT^3-IN^2
MAIN LOX VALVE RESISTANCE 675.9121000 S^2 PER FT^3-IN^2
MAIN FUEL VALVE RESISTANCE 1933.5280000 S^2 PER FT^3-IN^2

HEAT TRANSFER TO THE H2 IN THRUST CHAMBER 2859.2350000 BTU PER S
HEAT TRANSFER TO THE H2 IN NOZZLE 934.6414000 BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 1 116.0389000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 2 131.2649000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 3 121.8130000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 4 145.1343000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 5 130.7593000BTU PER S [illegible]
HEAT TRANSFER TO CALORIMETER CHANNEL 6 141.3126000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 7 148.1591000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 8 144.6893000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 9 110.6408000BTU PER S $\frac{Q_{avg}}{A_{avg}}$ = [illegible]
HEAT TRANSFER TO CALORIMETER CHANNEL 10 101.3511000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 11 124.2574000BTU PER S

LOX DENSITY UPSTREAM OF MOV 70.0532200 LBM PER FT^3
LH2 DENSITY UPSTREAM OF MFV 4.8785580 LBM PER FT^ 3
LH2 DENSITY INLET TO T.C. COOLANT JACKET 3.3421860 LBM PER FT^3
H2 DENSITY EXHAUST FROM T.C. COOLANT JACKET .6153337 LBM PER FT^3
H2 DENSITY INLET TO NOZZLE COOLANT JACKET .6023655 LBM PER FT^3
H2 DENSITY EXHAUST FROM NOZZLE COOLANT JACKET .4715411 LBM PER FT^3
H2O DENSITY CALORIMETER INLET MANIFOLD 63.0109600 LBM PER FT^3
CALORIMETER CHANNEL 1 INLET DENSITY 62.8875000 LBM PER FT^3
CALORIMETER CHANNEL 2 INLET DENSITY 62.8817500 LBM PER FT^3
CALORIMETER CHANNEL 3 INLET DENSITY 62.8783400 LBM PER FT^3
CALORIMETER CHANNEL 4 INLET DENSITY 62.8722800 LBM PER FT^3
CALORIMETER CHANNEL 5 INLET DENSITY 62.9065800 LBM PER FT^3
CALORIMETER CHANNEL 6 INLET DENSITY 62.8697800 LBM PER FT^3
CALORIMETER CHANNEL 7 INLET DENSITY 62.8768800 LBM PER FT^3
CALORIMETER CHANNEL 8 INLET DENSITY 62.8842200 LBM PER FT^3
CALORIMETER CHANNEL 9 INLET DENSITY 62.8926900 LBM PER FT^3
CALORIMETER CHANNEL 10 INLET DENSITY 62.8653900 LBM PER FT^3
CALORIMETER CHANNEL 11 INLET DENSITY 62.8709300 LBM PER FT^3
CALORIMETER CHANNEL 1 EXHAUST DENSITY 61.8763900 LBM PER FT^3
CALORIMETER CHANNEL 2 EXHAUST DENSITY 61.7952000 LBM PER FT^3
CALORIMETER CHANNEL 3 EXHAUST DENSITY 61.7711100 LBM PER FT^3
CALORIMETER CHANNEL 4 EXHAUST DENSITY 61.7517300 LBM PER FT^3
CALORIMETER CHANNEL 5 EXHAUST DENSITY 61.7322900 LBM PER FT^3
CALORIMETER CHANNEL 6 EXHAUST DENSITY 61.6421300 LBM PER FT^3
CALORIMETER CHANNEL 7 EXHAUST DENSITY 61.6359300 LBM PER FT^3
CALORIMETER CHANNEL 8 EXHAUST DENSITY 61.6795500 LBM PER FT^3

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CALORIMETER CHANNEL  9 EXHAUST DENSITY      61.8601200 LBM PER FT^3
CALORIMETER CHANNEL 10 EXHAUST DENSITY      61.9441000 LBM PER FT^3
CALORIMETER CHANNEL 11 EXHAUST DENSITY      61.8415800 LBM PER FT^3

  2 ENTHALPY INLET TO T.C. COOLANT JACKET      94.8955400 BTU PER LBM
GH2 ENTHALPY EXHAUST FROM T.C. COOLANT JACKET   1295.0960000 BTU PER LBM
GH2 ENTHALPY INLET TO NOZZLE COOLANT JACKET   1313.8850000 BTU PER LBM
GH2 ENTHALPY EXHAUST FROM NOZZLE COOLANT JACKET   1706.2130000 BTU PER LBM
CALORIMETER CHANNEL  1 INLET ENTHALPY     41.5521000 BTU PER LBM
CALORIMETER CHANNEL  2 INLET ENTHALPY     41.4692500 BTU PER LBM
CALORIMETER CHANNEL  3 INLET ENTHALPY     41.4199300 BTU PER LBM
CALORIMETER CHANNEL  4 INLET ENTHALPY     41.3309700 BTU PER LBM
CALORIMETER CHANNEL  5 INLET ENTHALPY     41.8285500 BTU PER LBM
CALORIMETER CHANNEL  6 INLET ENTHALPY     41.2952300 BTU PER LBM
CALORIMETER CHANNEL  7 INLET ENTHALPY     41.3976200 BTU PER LBM
CALORIMETER CHANNEL  8 INLET ENTHALPY     41.5051200 BTU PER LBM
CALORIMETER CHANNEL  9 INLET ENTHALPY     41.6276700 BTU PER LBM
CALORIMETER CHANNEL 10 INLET ENTHALPY     41.2317800 BTU PER LBM
CALORIMETER CHANNEL 11 INLET ENTHALPY     41.3114800 BTU PER LBM
CALORIMETER CHANNEL  1 EXHAUST ENTHALPY     100.0975000 BTU PER LBM
CALORIMETER CHANNEL  2 EXHAUST ENTHALPY     103.7536000 BTU PER LBM
CALORIMETER CHANNEL  3 EXHAUST ENTHALPY     104.9577000 BTU PER LBM
CALORIMETER CHANNEL  4 EXHAUST ENTHALPY     106.9653000 BTU PER LBM
CALORIMETER CHANNEL  5 EXHAUST ENTHALPY     108.1401000 BTU PER LBM
CALORIMETER CHANNEL  6 EXHAUST ENTHALPY     111.4677000 BTU PER LBM
CALORIMETER CHANNEL  7 EXHAUST ENTHALPY     112.7806000 BTU PER LBM
CALORIMETER CHANNEL  8 EXHAUST ENTHALPY     111.1956000 BTU PER LBM
CALORIMETER CHANNEL  9 EXHAUST ENTHALPY      99.5075200 BTU PER LBM
CALORIMETER CHANNEL 10 EXHAUST ENTHALPY      94.0117300 BTU PER LBM
CALORIMETER CHANNEL 11 EXHAUST ENTHALPY     100.7058000 BTU PER LBM

GOX VENTURI FLOW          .0497286 LBM PER S
  2 VENTURI FLOW          .0533710 LBM PER S
 OX INJECTOR FLOW       13.6590600 LBM PER S
GH2 INJECTOR FLOW        2.3822980 LBM PER S
CALORIMETER CHANNEL  1 H2O FLOW         1.9820330 LBM PER S
CALORIMETER CHANNEL  2 H2O FLOW         2.1075090 LBM PER S
CALORIMETER CHANNEL  3 H2O FLOW         1.9171730 LBM PER S
CALORIMETER CHANNEL  4 H2O FLOW         2.2112560 LBM PER S
CALORIMETER CHANNEL  5 H2O FLOW         1.9718940 LBM PER S
CALORIMETER CHANNEL  6 H2O FLOW         2.0137900 LBM PER S
CALORIMETER CHANNEL  7 H2O FLOW         2.0755530 LBM PER S
CALORIMETER CHANNEL  8 H2O FLOW         2.0761700 LBM PER S
CALORIMETER CHANNEL  9 H2O FLOW         1.9115590 LBM PER S
CALORIMETER CHANNEL 10 H2O FLOW         1.9202570 LBM PER S
CALORIMETER CHANNEL 11 H2O FLOW         2.0920770 LBM PER S

THE THEORETICAL CSTAR    8106.2280000
THE CSTAR     7966.8710000
CSTAR EFFICIENCY       98.2808700
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T = 173.0, MR:6.5 (VS. 5.9 ACTUAL)

LH2 PRESS. UPSTREAM OF THE MAIN FUEL VALVE 3747.0800000 PSIG
LH2 PRESS. DOWNSTREAM OF THE MAIN FUEL VALVE 1494.8300000 PSIG
LH2 PRESS. INLET TO THE THRUST CHAMBER COOLANT JACKET 1579.7400000 PSIG
H2 PRESS. EXHAUST FROM THE THRUST CHAMBER COOLING JACKET 1371.3500000 PSIG
PRESS. INLET TO THE NOZZLE COOLING JACKET 1357.0100000 PSIG
H2 PRESS. EXHAUST FROM THE NOZZLE COOLING JACKET 1328.3400000 PSIG
H2 PRESS. EXHAUST FROM THE NOZZLE COOLING JACKET-REDUNDANT 1328.3400000PSIG
NO PRESSURE AT P8
H2 PRESS. INLET TO THE FUEL MANIFOLD 971.4100000 PSIG
GH2 PRESS. INLET TO THE OLD FUEL MANIFOLD 925.2100000 PSIG
CALORIMETER CHANNEL 11 EXHAUST PRESSURE 1577.8500000 PSIG
CALORIMETER CHANNEL 12 EXHAUST PRESSURE 1500.2700000 PSIG
CALORIMETER CHANNEL 13 EXHAUST PRESSURE 1479.0400000 PSIG
CALORIMETER CHANNEL 14 EXHAUST PRESSURE 1544.7100000 PSIG
CALORIMETER CHANNEL 15 EXHAUST PRESSURE 1553.4100000 PSIG
CALORIMETER CHANNEL 16 EXHAUST PRESSURE 1407.0400000 PSIG
CALORIMETER CHANNEL 17 EXHAUST PRESSURE 1495.3900000 PSIG
CALORIMETER CHANNEL 18 EXHAUST PRESSURE 1552.7100000 PSIG
CALORIMETER CHANNEL 19 EXHAUST PRESSURE 1464.5100000 PSIG
CALORIMETER CHANNEL 20 EXHAUST PRESSURE 1436.7800000 PSIG
CALORIMETER CHANNEL 21 EXHAUST PRESSURE 1472.9100000 PSIG
LOX PRESS. INLET TO THE MAIN OXIDIZER VALVE 2739.1800000 PSIG
LOX PRESS. EXHAUST FROM THE MAIN OXIDIZER VALVE 940.2900000 PSIG
H2O PRESS. CALORIMETER INLET MANIFOLD 3486.6800000 PSIG
GOX PRESS. INLET TO THE IGNITER VENTURI 2021.7600000 PSIG
NO PRESSURE AT P26
GH2 PRESS. INLET TO THE IGNITER VENTURI 1964.7800000 PSIG
NO PRESSURE AT P28
LOX DOME HIGH FREQUENCY PRESSURE TRANSDUCER 2560.0000000 PSIG
CHAMBER PRESSURE 853.1500000 PSIG
CHAMBER PRESSURE 854.6700000 PSIG
IGNITER PRESSURE 889.0600000 PSIG
NITER PRESSURE 885.2700000 PSIG
X PRESS. EXHAUST FROM THE IGNITER VENTURI 885.3200000 PSIG
GH2 PRESS. EXHAUST FROM THE IGNITER VENTURI 988.9800000 PSIG
H2O PRESS. CALORIMETER EXHAUST PLENUM 760.8300000 PSIG
CALORIMETER CHANNEL 1 INLET PRESSURE 2852.6900000 PSIG
CALORIMETER CHANNEL 2 INLET PRESSURE 2844.1100000 PSIG
CALORIMETER CHANNEL 3 INLET PRESSURE 2801.2900000 PSIG
CALORIMETER CHANNEL 4 INLET PRESSURE 2762.5900000 PSIG
CALORIMETER CHANNEL 5 INLET PRESSURE 2943.0400000 PSIG
CALORIMETER CHANNEL 6 INLET PRESSURE 2714.4500000 PSIG
CALORIMETER CHANNEL 7 INLET PRESSURE 2780.2400000 PSIG
CALORIMETER CHANNEL 8 INLET PRESSURE 2819.7700000 PSIG
CALORIMETER CHANNEL 9 INLET PRESSURE 2876.5300000 PSIG
CALORIMETER CHANNEL 10 INLET PRESSURE 2726.3100000 PSIG
CALORIMETER CHANNEL 11 INLET PRESSURE 2783.2400000 PSIG

LH2 TEMP. UPSTREAM OF THE MAIN FUEL VALVE -380.0000000 DEG F
LH2 TEMP. DOWNSTREAM OF THE MAIN FUEL VALVE -380.0000000 DEG F
LH2 TEMP. INLET TO THE THRUST CHAMBER COOLING JACKET -364.3100000 DEG F
H2 TEMP. EXHAUST FROM THE THRUST CHAMBER COOLING JACKET -36.6800000 DEG F
H2 TEMP. INLET TO THE NOZZLE COOLING JACKET -35.2000000 DEG F
H2 TEMP. EXHAUST FROM THE NOZZLE COOLING JACKET 80.7600000 DEG F
LOX TEMP. INLET TO THE MAIN OXIDIZER VALVE -276.9900000 DEG F
LOX TEMP. EXHAUST FROM THE MAIN OXIDIZER VALVE -276.9900000 DEG F
H2 TEMP. INLET TO THE FUEL MANIFOLD 80.8100000 DEG F
GH2 TEMP. INLET TO THE OLD FUEL MANIFOLD 77.8400000 DEG F
CALORIMETER CHANNEL 11 EXHAUST TEMP. 128.9500000 DEG F
CALORIMETER CHANNEL 12 EXHAUST TEMP. 132.0100000 DEG F
CALORIMETER CHANNEL 13 EXHAUST TEMP. 134.2400000 DEG F
LORIMETER CHANNEL 14 EXHAUST TEMP. 136.6400000 DEG F
CALORIMETER CHANNEL 15 EXHAUST TEMP. 137.3600000 DEG F
CALORIMETER CHANNEL 16 EXHAUST TEMP. 140.6900000 DEG F
CALORIMETER CHANNEL 17 EXHAUST TEMP. 142.0400000 DEG F
CALORIMETER CHANNEL 18 EXHAUST TEMP. 140.3300000 DEG F

CALORIMETER CHANNEL 19 EXHAUST TEMP. 128.8900000 DEG F
CALORIMETER CHANNEL 20 EXHAUST TEMP. 124.5100000 DEG F
CALORIMETER CHANNEL 21 EXHAUST TEMP. 132.3000000 DEG F
OX TEMP. INLET TO THE IGNITER VENTURI 59.5100000 DEG F
2 TEMP. INLET TO THE IGNITER VENTURI 76.4600000 DEG F
H2O TEMP. CALORIMETER INLET MANIFOLD 64.4900000 DE G F
TEMP. MAIN OXIDIZER VALVE OPERATOR 35.0400000 DEG F
TEMP. MAIN FUEL VALVE OPERATOR 83.6700000 DEG F
H2O TEMP. CALORIMETER EXHAUST PLENUM 94.5800000 DE G F

LOX PRESS. UPSTREAM OF SYSTEM VENTURI 2776.4000000 P SIG
LOX PRESS. DOWNSTREAM OF SYSTEM VENTURI 2736.1300000 PSIG
LH2 PRESS. UPSTREAM OF SYSTEM VENTURI 3751.5500000 P SIG
LH2 PRESS. DOWNSTREAM OF SYSTEM VENTURI 3724.7300000 PSIG

LOX TEMP. UPSTREAM OF THE SYSTEM VENTURI -280.1400000 DEG F
LH2 TEMP. UPSTREAM OF THE SYSTEM VENTURI -380.6200000 DEG F

THE NOZZLE MIXTURE RATIO IS 4.6559310

THE INJECTOR MIXTURE RATIO IS 5.8404290

CORRECTED CALORIMETER CHANNEL 1 INLET PRESS. 2832.4900000 PSIG
CORRECTED CALORIMETER CHANNEL 2 INLET PRESS. 2832.7100000 PSIG
CORRECTED CALORIMETER CHANNEL 3 INLET PRESS. 2783.8900000 PSIG
CORRECTED CALORIMETER CHANNEL 4 INLET PRESS. 2744.3900000 PSIG
CORRECTED CALORIMETER CHANNEL 5 INLET PRESS. 2932.1400000 PSIG
CORRECTED CALORIMETER CHANNEL 6 INLET PRESS. 2707.8500000 PSIG
CORRECTED CALORIMETER CHANNEL 7 INLET PRESS. 2769.4400000 PSIG
CORRECTED CALORIMETER CHANNEL 8 INLET PRESS. 2807.5700000 PSIG
CORRECTED CALORIMETER CHANNEL 9 INLET PRESS. 2862.6300000 PSIG
CORRECTED CALORIMETER CHANNEL 10 INLET PRESS. 2713.5100000 PSIG
RRECTED CALORIMETER CHANNEL 11 INLET PRESS. 2766.4400000 PSIG

CALORIMETER CHANNEL 1 EXHAUST SATURATION PRESS. 2.1636140 PSIA
CALORIMETER CHANNEL 2 EXHAUST SATURATION PRESS. 2.3475600 PSIA
CALORIMETER CHANNEL 3 EXHAUST SATURATION PRESS. 2.4898830 PSIA
CALORIMETER CHANNEL 4 EXHAUST SATURATION PRESS. 2.6512110 PSIA
CALORIMETER CHANNEL 5 EXHAUST SATURATION PRESS. 2.7013110 PSIA
CALORIMETER CHANNEL 6 EXHAUST SATURATION PRESS. 2.9436650 PSIA
CALORIMETER CHANNEL 7 EXHAUST SATURATION PRESS. 3.0470650 PSIA
CALORIMETER CHANNEL 8 EXHAUST SATURATION PRESS. 2.9166060 PSIA
CALORIMETER CHANNEL 9 EXHAUST SATURATION PRESS. 2.1601340 PSIA
CALORIMETER CHANNEL 10 EXHAUST SATURATION PRESS. 1.9186900 PSIA
CALORIMETER CHANNEL 11 EXHAUST SATURATION PRESS. 2.3656690 PSIA

THE CALORIMETER EXHAUST PLENUM SATURATION PRESSURE .8057542 PSIA

COOLANT PRESSURE DROP ACROSS THRUST CHAMBER 208.3900000 PSID
COOLANT PRESSURE DROP ACROSS NOZZLE 28.6700400 PSID
CALORIMETER CHANNEL 1 PRESSURE DROP 1254.6400000 PSID
CALORIMETER CHANNEL 2 PRESSURE DROP 1332.4400000 PSID
CALORIMETER CHANNEL 3 PRESSURE DROP 1304.8500000 PSID
CALORIMETER CHANNEL 4 PRESSURE DROP 1199.6800000 PSID
CALORIMETER CHANNEL 5 PRESSURE DROP 1378.7300000 PSID
CALORIMETER CHANNEL 6 PRESSURE DROP 1300.8100000 PSID
CALORIMETER CHANNEL 7 PRESSURE DROP 1274.0500000 PSID
CALORIMETER CHANNEL 8 PRESSURE DROP 1254.8600000 PSID
CALORIMETER CHANNEL 9 PRESSURE DROP 1398.1200000 PSID
CALORIMETER CHANNEL 10 PRESSURE DROP 1276.7300000 PSID
ALORIMETER CHANNEL 11 PRESSURE DROP 1293.5300000 PSID

COOLANT TEMP. RISE THROUGH THE THRUST CHAMBER 327.6300000 DEG F
COOLANT TEMP. RISE THROUGH THE NOZZLE 115.9600000 DEG F
CALORIMETER CHANNEL 1 TEMP. RISE 64.4599600 DEG F
CALORIMETER CHANNEL 2 TEMP. RISE 67.5199600 DEG F

CALORIMETER CHANNEL 3 TEMP. RISE	69.7500000	DEG F
CALORIMETER CHANNEL 4 TEMP. RISE	72.1499600	DEG F
CALORIMETER CHANNEL 5 TEMP. RISE	72.8700000	DEG F
CALORIMETER CHANNEL 6 TEMP. RISE	76.1999500	DEG F
CALORIMETER CHANNEL 7 TEMP. RISE	77.5499900	DEG F
CALORIMETER CHANNEL 8 TEMP. RISE	75.8399700	DEG F
CALORIMETER CHANNEL 9 TEMP. RISE	64.3999600	DEG F
CALORIMETER CHANNEL 10 TEMP. RISE	60.0199600	DEG F
CALORIMETER CHANNEL 11 TEMP. RISE	67.8100000	DEG F
THRUST CHAMBER COOLANT JACKET RESISTANCE	126.9958000	S^2 PER FT^3-IN^2
NOZZLE COOLANT JACKET RESISTANCE	3.0730230	S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 1 RESISTANCE	20059.3800000	S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 2 RESISTANCE	19734.6400000	S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 3 RESISTANCE	22282.0600000	S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 4 RESISTANCE	15239.9300000	S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 5 RESISTANCE	22242.3400000	S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 6 RESISTANCE	19326.6100000	S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 7 RESISTANCE	18389.7400000	S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 8 RESISTANCE	18072.3300000	S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 9 RESISTANCE	24144.9800000	S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 10 RESISTANCE	21667.2700000	S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 11 RESISTANCE	19123.1600000	S^2 PER FT^3-IN^2
MAIN LOX VALVE RESISTANCE	673.2639000	S^2 PER FT^3-IN^2
MAIN FUEL VALVE RESISTANCE	1982.2380000	S^2 PER FT^3-IN^2
HEAT TRANSFER TO THE H2 IN THRUST CHAMBER	2968.0640000	BTU PER S
HEAT TRANSFER TO THE H2 IN NOZZLE	983.2320000	BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 1	119.8508000	BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 2	130.3808000	BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 3	125.8195000	BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 4	151.7791000	BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 5	135.1556000	BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 6	148.1192000	BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 7	153.1917000	BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 8	149.8965000	BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 9	114.5068000	BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 10	107.7742000	BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 11	131.3150000	BTU PER S
LOX DENSITY UPSTREAM OF MOV	70.4993100	LBM PER FT^3
LH2 DENSITY UPSTREAM OF MFV	4.6765270	LBM PER FT^ 3
LH2 DENSITY INLET TO T.C. COOLANT JACKET	3.2381470	LBM PER FT^3
H2 DENSITY EXHAUST FROM T.C. COOLANT JACKET	.5770505	LBM PER FT^3
H2 DENSITY INLET TO NOZZLE COOLANT JACKET	.5695366	LBM PER FT^3
H2 DENSITY EXHAUST FROM NOZZLE COOLANT JACKET	.4419635	LBM PER FT^3
H2O DENSITY CALORIMETER INLET MANIFOLD	63.0210800	LBM PER FT^3
CALORIMETER CHANNEL 1 INLET DENSITY	62.8971900	LBM PER FT^3
CALORIMETER CHANNEL 2 INLET DENSITY	62.8972100	LBM PER FT^3
CALORIMETER CHANNEL 3 INLET DENSITY	62.8879100	LBM PER FT^3
CALORIMETER CHANNEL 4 INLET DENSITY	62.8803900	LBM PER FT^3
CALORIMETER CHANNEL 5 INLET DENSITY	62.9161300	LBM PER FT^3
CALORIMETER CHANNEL 6 INLET DENSITY	62.8734400	LBM PER FT^3
CALORIMETER CHANNEL 7 INLET DENSITY	62.8851700	LBM PER FT^3
CALORIMETER CHANNEL 8 INLET DENSITY	62.8924200	LBM PER FT^3
CALORIMETER CHANNEL 9 INLET DENSITY	62.9029200	LBM PER FT^3
CALORIMETER CHANNEL 10 INLET DENSITY	62.8744800	LBM PER FT^3
CALORIMETER CHANNEL 11 INLET DENSITY	62.8846300	LBM PER FT^3
CALORIMETER CHANNEL 1 EXHAUST DENSITY	61.8627300	LBM PER FT^3
CALORIMETER CHANNEL 2 EXHAUST DENSITY	61.7969500	LBM PER FT^3
CALORIMETER CHANNEL 3 EXHAUST DENSITY	61.7548500	LBM PER FT^3
CALORIMETER CHANNEL 4 EXHAUST DENSITY	61.7251500	LBM PER FT^3
CALORIMETER CHANNEL 5 EXHAUST DENSITY	61.7141300	LBM PER FT^3
CALORIMETER CHANNEL 6 EXHAUST DENSITY	61.6280900	LBM PER FT^3
CALORIMETER CHANNEL 7 EXHAUST DENSITY	61.6200000	LBM PER FT^3
CALORIMETER CHANNEL 8 EXHAUST DENSITY	61.6612900	LBM PER FT^3

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CALORIMETER CHANNEL  9 EXHAUST DENSITY       61.8429500 LBM PER FT^3
CALORIMETER CHANNEL 10 EXHAUST DENSITY       61.9097900 LBM PER FT^3
CALORIMETER CHANNEL 11 EXHAUST DENSITY       61.7870000 LBM PER FT^3

 2 ENTHALPY INLET TO T.C. COOLANT JACKET      104.9529000 BTU PER LBM
GH2 ENTHALPY EXHAUST FROM T.C. COOLANT JACKET    1392.5540000 BTU PER LBM
GH2 ENTHALPY INLET TO NOZZLE COOLANT JACKET    1398.0360000 BTU PER LBM
GH2 ENTHALPY EXHAUST FROM NOZZLE COOLANT JACKET    1824.5800000 BTU PER LBM
CALORIMETER CHANNEL  1 INLET ENTHALPY      40.5091700 BTU PER LBM
CALORIMETER CHANNEL  2 INLET ENTHALPY      40.5090800 BTU PER LBM
CALORIMETER CHANNEL  3 INLET ENTHALPY      40.3754800 BTU PER LBM
CALORIMETER CHANNEL  4 INLET ENTHALPY      40.2659800 BTU PER LBM
CALORIMETER CHANNEL  5 INLET ENTHALPY      40.7838100 BTU PER LBM
CALORIMETER CHANNEL  6 INLET ENTHALPY      40.1650300 BTU PER LBM
CALORIMETER CHANNEL  7 INLET ENTHALPY      40.3348400 BTU PER LBM
CALORIMETER CHANNEL  8 INLET ENTHALPY      40.4407200 BTU PER LBM
CALORIMETER CHANNEL  9 INLET ENTHALPY      40.5923400 BTU PER LBM
CALORIMETER CHANNEL 10 INLET ENTHALPY      40.1799700 BTU PER LBM
CALORIMETER CHANNEL 11 INLET ENTHALPY      40.3273800 BTU PER LBM
CALORIMETER CHANNEL  1 EXHAUST ENTHALPY     100.9352000 BTU PER LBM
CALORIMETER CHANNEL  2 EXHAUST ENTHALPY     103.7777000 BTU PER LBM
CALORIMETER CHANNEL  3 EXHAUST ENTHALPY     105.9389000 BTU PER LBM
CALORIMETER CHANNEL  4 EXHAUST ENTHALPY     108.4862000 BTU PER LBM
CALORIMETER CHANNEL  5 EXHAUST ENTHALPY     109.2228000 BTU PER LBM
CALORIMETER CHANNEL  6 EXHAUST ENTHALPY     112.1677000 BTU PER LBM
CALORIMETER CHANNEL  7 EXHAUST ENTHALPY     113.7280000 BTU PER LBM
CALORIMETER CHANNEL  8 EXHAUST ENTHALPY     112.1709000 BTU PER LBM
CALORIMETER CHANNEL  9 EXHAUST ENTHALPY     100.5904000 BTU PER LBM
CALORIMETER CHANNEL 10 EXHAUST ENTHALPY      96.1725200 BTU PER LBM
CALORIMETER CHANNEL 11 EXHAUST ENTHALPY     103.9972000 BTU PER LBM

GOX VENTURI FLOW           .0495820 LBM PER S
 2 VENTURI FLOW            .0533204 LBM PER S
 X INJECTOR FLOW         13.7246800 LBM PER S
GH2 INJECTOR FLOW         2.3051120 LBM PER S
CALORIMETER CHANNEL  1 H2O FLOW        1.9834280 LBM PER S
CALORIMETER CHANNEL  2 H2O FLOW        2.0607480 LBM PER S
CALORIMETER CHANNEL  3 H2O FLOW        1.9190500 LBM PER S
CALORIMETER CHANNEL  4 H2O FLOW        2.2248400 LBM PER S
CALORIMETER CHANNEL  5 H2O FLOW        1.9748330 LBM PER S
CALORIMETER CHANNEL  6 H2O FLOW        2.0571340 LBM PER S
CALORIMETER CHANNEL  7 H2O FLOW        2.0872750 LBM PER S
CALORIMETER CHANNEL  8 H2O FLOW        2.0897280 LBM PER S
CALORIMETER CHANNEL  9 H2O FLOW        1.9085090 LBM PER S
CALORIMETER CHANNEL 10 H2O FLOW        1.9247960 LBM PER S
CALORIMETER CHANNEL 11 H2O FLOW        2.0624370 LBM PER S

THE THEORETICAL CSTAR     8071.2590000
THE CSTAR     7950.6300000
CSTAR EFFICIENCY        98.5054600
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T = 176.0, MR:7.0 (VS. 6.1 ACTUAL)

LH2 PRESS. UPSTREAM OF THE MAIN FUEL VALVE 3744.1800000 PSIG
LH2 PRESS. DOWNSTREAM OF THE MAIN FUEL VALVE 1483.5600000 PSIG
LH2 PRESS. INLET TO THE THRUST CHAMBER COOLANT JACKET 1561.3500000 PSIG
H2 PRESS. EXHAUST FROM THE THRUST CHAMBER COOLING JACKET 1362.1800000 PSIG
H2 PRESS. INLET TO THE NOZZLE COOLING JACKET 1347.9600000 PSIG
PRESS. EXHAUST FROM THE NOZZLE COOLING JACKET 1321.2800000 PSIG
H2 PRESS. EXHAUST FROM THE NOZZLE COOLING JACKET-REDUNDANT 1321.2900000PSIG
NO PRESSURE AT P8
H2 PRESS. INLET TO THE FUEL MANIFOLD 971.2100000 PSIG
GH2 PRESS. INLET TO THE OLD FUEL MANIFOLD 926.3300000 PSIG
CALORIMETER CHANNEL 11 EXHAUST PRESSURE 1577.6800000 PSIG
CALORIMETER CHANNEL 12 EXHAUST PRESSURE 1491.8900000 PSIG
CALORIMETER CHANNEL 13 EXHAUST PRESSURE 1478.5600000 PSIG
CALORIMETER CHANNEL 14 EXHAUST PRESSURE 1539.6400000 PSIG
CALORIMETER CHANNEL 15 EXHAUST PRESSURE 1557.0000000 PSIG
CALORIMETER CHANNEL 16 EXHAUST PRESSURE 1408.9200000 PSIG
CALORIMETER CHANNEL 17 EXHAUST PRESSURE 1495.8900000 PSIG
CALORIMETER CHANNEL 18 EXHAUST PRESSURE 1549.4700000 PSIG
CALORIMETER CHANNEL 19 EXHAUST PRESSURE 1462.7300000 PSIG
CALORIMETER CHANNEL 20 EXHAUST PRESSURE 1433.1500000 PSIG
CALORIMETER CHANNEL 21 EXHAUST PRESSURE 1469.4400000 PSIG
LOX PRESS. INLET TO THE MAIN OXIDIZER VALVE 2737.5100000 PSIG
LOX PRESS. EXHAUST FROM THE MAIN OXIDIZER VALVE 944.9300000 PSIG
H2O PRESS. CALORIMETER INLET MANIFOLD 3478.4400000 PSIG
GOX PRESS. INLET TO THE IGNITER VENTURI 2007.9000000 PSIG
NO PRESSURE AT P26
GH2 PRESS. INLET TO THE IGNITER VENTURI 1964.9000000 PSIG
NO PRESSURE AT P28
LOX DOME HIGH FREQUENCY PRESSURE TRANSDUCER 2560.0000000 PSIG
CHAMBER PRESSURE 853.4300000 PSIG
CHAMBER PRESSURE 855.2400000 PSIG
IGNITER PRESSURE 888.8000000 PSIG
IGNITER PRESSURE 885.1200000 PSIG
X PRESS. EXHAUST FROM THE IGNITER VENTURI 886.3500000 PSIG
2 PRESS. EXHAUST FROM THE IGNITER VENTURI 989.6900000 PSIG
H2O PRESS. CALORIMETER EXHAUST PLENUM 760.1600000 PSIG
CALORIMETER CHANNEL 1 INLET PRESSURE 2846.2500000 PSIG
CALORIMETER CHANNEL 2 INLET PRESSURE 2820.3300000 PSIG
CALORIMETER CHANNEL 3 INLET PRESSURE 2799.4700000 PSIG
CALORIMETER CHANNEL 4 INLET PRESSURE 2765.5900000 PSIG
CALORIMETER CHANNEL 5 INLET PRESSURE 2976.7700000 PSIG
CALORIMETER CHANNEL 6 INLET PRESSURE 2715.1300000 PSIG
CALORIMETER CHANNEL 7 INLET PRESSURE 2792.4900000 PSIG
CALORIMETER CHANNEL 8 INLET PRESSURE 2804.7800000 PSIG
CALORIMETER CHANNEL 9 INLET PRESSURE 2870.3900000 PSIG
CALORIMETER CHANNEL 10 INLET PRESSURE 2714.6200000 PSIG
CALORIMETER CHANNEL 11 INLET PRESSURE 2766.7800000 PSIG

LH2 TEMP. UPSTREAM OF THE MAIN FUEL VALVE -384.0000000 DEG F
LH2 TEMP. DOWNSTREAM OF THE MAIN FUEL VALVE -384.0000000 DEG F
LH2 TEMP. INLET TO THE THRUST CHAMBER COOLING JACKET -365.8100000 DEG F
H2 TEMP. EXHAUST FROM THE THRUST CHAMBER COOLING JACKET -13.5900000 DEG F
H2 TEMP. INLET TO THE NOZZLE COOLING JACKET -13.6500000 DEG F
H2 TEMP. EXHAUST FROM THE NOZZLE COOLING JACKET 116.0500000 DEG F
LOX TEMP. INLET TO THE MAIN OXIDIZER VALVE -278.3900000 DEG F
LOX TEMP. EXHAUST FROM THE MAIN OXIDIZER VALVE -278.3900000 DEG F
H2 TEMP. INLET TO THE FUEL MANIFOLD 116.3800000 DEG F
GH2 TEMP. INLET TO THE OLD FUEL MANIFOLD 78.6200000 DEG F
CALORIMETER CHANNEL 11 EXHAUST TEMP. 129.2900000 DEG F
CALORIMETER CHANNEL 12 EXHAUST TEMP. 132.7700000 DEG F
CALORIMETER CHANNEL 13 EXHAUST TEMP. 134.7300000 DEG F
LORIMETER CHANNEL 14 EXHAUST TEMP. 137.3100000 DEG F
LORIMETER CHANNEL 15 EXHAUST TEMP. 138.1500000 DEG F
CALORIMETER CHANNEL 16 EXHAUST TEMP. 141.6500000 DEG F
CALORIMETER CHANNEL 17 EXHAUST TEMP. 142.9900000 DEG F
CALORIMETER CHANNEL 18 EXHAUST TEMP. 143.0600000 DEG F

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CALORIMETER CHANNEL 19 EXHAUST TEMP.          130.6200000 DEG F
CALORIMETER CHANNEL 20 EXHAUST TEMP.          126.2500000 DEG F
CALORIMETER CHANNEL 21 EXHAUST TEMP.          135.1900000 DEG F
GOX TEMP. INLET TO THE IGNITER VENTURI          61.3200000 DEG F
GH2 TEMP. INLET TO THE IGNITER VENTURI          78.1400000 DEG F
H2O TEMP. CALORIMETER INLET MANIFOLD          64.4900000 DE G F
TEMP. MAIN OXIDIZER VALVE OPERATOR          35.1300000 DEG F
TEMP. MAIN FUEL VALVE OPERATOR          82.6600000 DEG F
H2O TEMP. CALORIMETER EXHAUST PLENUM          93.7300000 DE G F

LOX PRESS. UPSTREAM OF SYSTEM VENTURI          2774.3900000 P SIG
LOX PRESS. DOWNSTREAM OF SYSTEM VENTURI          2733.2700000 PSIG
LH2 PRESS. UPSTREAM OF SYSTEM VENTURI          3746.0900000 P SIG
LH2 PRESS. DOWNSTREAM OF SYSTEM VENTURI          3721.4500000 PSIG

LOX TEMP. UPSTREAM OF THE SYSTEM VENTURI          -280.4900000 DEG F
LH2 TEMP. UPSTREAM OF THE SYSTEM VENTURI          -382.9300000 DEG F

THE NOZZLE MIXTURE RATIO IS          4.8371660

THE INJECTOR MIXTURE RATIO IS          6.1092580

CORRECTED CALORIMETER CHANNEL  1 INLET PRESS.          2826.0500000 PSIG
CORRECTED CALORIMETER CHANNEL  2 INLET PRESS.          2808.9300000 PSIG
CORRECTED CALORIMETER CHANNEL  3 INLET PRESS.          2782.0700000 PSIG
CORRECTED CALORIMETER CHANNEL  4 INLET PRESS.          2747.3900000 PSIG
CORRECTED CALORIMETER CHANNEL  5 INLET PRESS.          2965.8700000 PSIG
CORRECTED CALORIMETER CHANNEL  6 INLET PRESS.          2708.5300000 PSIG
CORRECTED CALORIMETER CHANNEL  7 INLET PRESS.          2781.6900000 PSIG
CORRECTED CALORIMETER CHANNEL  8 INLET PRESS.          2792.5800000 PSIG
CORRECTED CALORIMETER CHANNEL  9 INLET PRESS.          2856.4900000 PSIG
CORRECTED CALORIMETER CHANNEL 10 INLET PRESS.          2701.8200000 PSIG
CORRECTED CALORIMETER CHANNEL 11 INLET PRESS.          2749.9800000 PSIG

CALORIMETER CHANNEL  1 EXHAUST SATURATION PRESS.          2.1834240 PSIA
CALORIMETER CHANNEL  2 EXHAUST SATURATION PRESS.          2.3952600 PSIA
CALORIMETER CHANNEL  3 EXHAUST SATURATION PRESS.          2.5221210 PSIA
CALORIMETER CHANNEL  4 EXHAUST SATURATION PRESS.          2.6978040 PSIA
CALORIMETER CHANNEL  5 EXHAUST SATURATION PRESS.          2.7572100 PSIA
CALORIMETER CHANNEL  6 EXHAUST SATURATION PRESS.          3.0168810 PSIA
CALORIMETER CHANNEL  7 EXHAUST SATURATION PRESS.          3.1216610 PSIA
CALORIMETER CHANNEL  8 EXHAUST SATURATION PRESS.          3.1272160 PSIA
CALORIMETER CHANNEL  9 EXHAUST SATURATION PRESS.          2.2624170 PSIA
CALORIMETER CHANNEL 10 EXHAUST SATURATION PRESS.          2.0116850 PSIA
CALORIMETER CHANNEL 11 EXHAUST SATURATION PRESS.          2.5527080 PSIA

THE CALORIMETER EXHAUST PLENUM SATURATION PRESSURE          .7849099 PSIA

COOLANT PRESSURE DROP ACROSS THRUST CHAMBER          199.1699000 PSID
COOLANT PRESSURE DROP ACROSS NOZZLE          26.6799300 PSID
CALORIMETER CHANNEL  1 PRESSURE DROP          1248.3700000 PSID
CALORIMETER CHANNEL  2 PRESSURE DROP          1317.0400000 PSID
CALORIMETER CHANNEL  3 PRESSURE DROP          1303.5100000 PSID
CALORIMETER CHANNEL  4 PRESSURE DROP          1207.7500000 PSID
CALORIMETER CHANNEL  5 PRESSURE DROP          1408.8700000 PSID
CALORIMETER CHANNEL  6 PRESSURE DROP          1299.6100000 PSID
CALORIMETER CHANNEL  7 PRESSURE DROP          1285.8000000 PSID
CALORIMETER CHANNEL  8 PRESSURE DROP          1243.1100000 PSID
CALORIMETER CHANNEL  9 PRESSURE DROP          1393.7600000 PSID
CALORIMETER CHANNEL 10 PRESSURE DROP          1268.6700000 PSID
CALORIMETER CHANNEL 11 PRESSURE DROP          1280.5400000 PSID

COOLANT TEMP. RISE THROUGH THE THRUST CHAMBER          352.2200000 DEG F
COOLANT TEMP. RISE THROUGH THE NOZZLE          129.7000000 DEG F
CALORIMETER CHANNEL  1 TEMP. RISE          64.7999900 DEG F
CALORIMETER CHANNEL  2 TEMP. RISE          68.2799700 DEG F
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CALORIMETER CHANNEL 3 TEMP. RISE 70.2399900 DEG F
CALORIMETER CHANNEL 4 TEMP. RISE 72.8199500 DEG F
CALORIMETER CHANNEL 5 TEMP. RISE 73.6599700 DEG F
CALORIMETER CHANNEL 6 TEMP. RISE 77.1599700 DEG F
CALORIMETER CHANNEL 7 TEMP. RISE 78.5000000 DEG F
CALORIMETER CHANNEL 8 TEMP. RISE 78.5699500 DEG F
CALORIMETER CHANNEL 9 TEMP. RISE 66.1300000 DEG F
CALORIMETER CHANNEL 10 TEMP. RISE 61.7600100 DEG F
CALORIMETER CHANNEL 11 TEMP. RISE 70.6999500 DEG F

THRUST CHAMBER COOLANT JACKET RESISTANCE 131.2498000 S^2 PER FT^3-IN^2
NOZZLE COOLANT JACKET RESISTANCE 2.8988520 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 1 RESISTANCE 20016.0700000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 2 RESISTANCE 19045.0500000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 3 RESISTANCE 22470.1000000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 4 RESISTANCE 15584.9000000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 5 RESISTANCE 24633.1800000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 6 RESISTANCE 19534.9400000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 7 RESISTANCE 19114.9200000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 8 RESISTANCE 17723.3700000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 9 RESISTANCE 24152.9600000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 10 RESISTANCE 21433.0100000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 11 RESISTANCE 18711.9800000 S^2 PER FT^3-IN^2
MAIN LOX VALVE RESISTANCE 657.0362000 S^2 PER FT^3-IN^2
MAIN FUEL VALVE RESISTANCE 2165.6260000 S^2 PER FT^3-IN^2

HEAT TRANSFER TO THE H2 IN THRUST CHAMBER 3074.7590000 BTU PER S
HEAT TRANSFER TO THE H2 IN NOZZLE 1052.9320000 BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 1 120.3805000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 2 133.6118000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 3 126.1642000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 4 152.0168000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 5 131.1607000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 6 149.2156000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 7 152.8255000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 8 156.4194000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 9 117.6044000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 10 111.3917000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 11 138.1094000BTU PER S

LOX DENSITY UPSTREAM OF MOV 70.7084700 LBM PER FT^3
LH2 DENSITY UPSTREAM OF MFV 4.7565750 LBM PER FT^ 3
LH2 DENSITY INLET TO T.C. COOLANT JACKET 3.2720000 LBM PER FT^3
H2 DENSITY EXHAUST FROM T.C. COOLANT JACKET .5446880 LBM PER FT^3
H2 DENSITY INLET TO NOZZLE COOLANT JACKET .5394854 LBM PER FT^3
H2 DENSITY EXHAUST FROM NOZZLE COOLANT JACKET .4136847 LBM PER FT^3
H2O DENSITY CALORIMETER INLET MANIFOLD 63.0195200 LBM PER FT^3
CALORIMETER CHANNEL 1 INLET DENSITY 62.8959700 LBM PER FT^3
CALORIMETER CHANNEL 2 INLET DENSITY 62.8927000 LBM PER FT^3
CALORIMETER CHANNEL 3 INLET DENSITY 62.8876100 LBM PER FT^3
CALORIMETER CHANNEL 4 INLET DENSITY 62.8809700 LBM PER FT^3
CALORIMETER CHANNEL 5 INLET DENSITY 62.9225400 LBM PER FT^3
CALORIMETER CHANNEL 6 INLET DENSITY 62.8735600 LBM PER FT^3
CALORIMETER CHANNEL 7 INLET DENSITY 62.8875300 LBM PER FT^3
CALORIMETER CHANNEL 8 INLET DENSITY 62.8896200 LBM PER FT^3
CALORIMETER CHANNEL 9 INLET DENSITY 62.9017600 LBM PER FT^3
CALORIMETER CHANNEL 10 INLET DENSITY 62.8722700 LBM PER FT^3
CALORIMETER CHANNEL 11 INLET DENSITY 62.8814700 LBM PER FT^3
CALORIMETER CHANNEL 1 EXHAUST DENSITY 61.8570200 LBM PER FT^3
CALORIMETER CHANNEL 2 EXHAUST DENSITY 61.7824700 LBM PER FT^3
CALORIMETER CHANNEL 3 EXHAUST DENSITY 61.7463000 LBM PER FT^3
CALORIMETER CHANNEL 4 EXHAUST DENSITY 61.7124600 LBM PER FT^3
CALORIMETER CHANNEL 5 EXHAUST DENSITY 61.7008600 LBM PER FT^3
CALORIMETER CHANNEL 6 EXHAUST DENSITY 61.6111700 LBM PER FT^3
CALORIMETER CHANNEL 7 EXHAUST DENSITY 61.6028700 LBM PER FT^3
CALORIMETER CHANNEL 8 EXHAUST DENSITY 61.6114500 LBM PER FT^3

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CALORIMETER CHANNEL  9 EXHAUST DENSITY        61.8136000 LBM PER FT^3
CALORIMETER CHANNEL 10 EXHAUST DENSITY        61.8808100 LBM PER FT^3
CALORIMETER CHANNEL 11 EXHAUST DENSITY        61.7366300 LBM PER FT^3

GH2 ENTHALPY INLET TO T.C. COOLANT JACKET       99.6481200 BTU PER LBM
GH2 ENTHALPY EXHAUST FROM T.C. COOLANT JACKET     1479.5300000 BTU PER LBM
GH2 ENTHALPY INLET TO NOZZLE COOLANT JACKET     1479.1550000 BTU PER LBM
GH2 ENTHALPY EXHAUST FROM NOZZLE COOLANT JACKET     1951.6870000 BTU PER LBM
CALORIMETER CHANNEL  1 INLET ENTHALPY        40.4917500 BTU PER LBM
CALORIMETER CHANNEL  2 INLET ENTHALPY        40.4441200 BTU PER LBM
CALORIMETER CHANNEL  3 INLET ENTHALPY        40.3702500 BTU PER LBM
CALORIMETER CHANNEL  4 INLET ENTHALPY        40.2744600 BTU PER LBM
CALORIMETER CHANNEL  5 INLET ENTHALPY        40.8770500 BTU PER LBM
CALORIMETER CHANNEL  6 INLET ENTHALPY        40.1672400 BTU PER LBM
CALORIMETER CHANNEL  7 INLET ENTHALPY        40.3689900 BTU PER LBM
CALORIMETER CHANNEL  8 INLET ENTHALPY        40.3986100 BTU PER LBM
CALORIMETER CHANNEL  9 INLET ENTHALPY        40.5754200 BTU PER LBM
CALORIMETER CHANNEL 10 INLET ENTHALPY        40.1485100 BTU PER LBM
CALORIMETER CHANNEL 11 INLET ENTHALPY        40.2815000 BTU PER LBM
CALORIMETER CHANNEL  1 EXHAUST ENTHALPY       101.2720000 BTU PER LBM
CALORIMETER CHANNEL  2 EXHAUST ENTHALPY       104.5114000 BTU PER LBM
CALORIMETER CHANNEL  3 EXHAUST ENTHALPY       106.4242000 BTU PER LBM
CALORIMETER CHANNEL  4 EXHAUST ENTHALPY       109.1390000 BTU PER LBM
CALORIMETER CHANNEL  5 EXHAUST ENTHALPY       110.0164000 BTU PER LBM
CALORIMETER CHANNEL  6 EXHAUST ENTHALPY       113.1264000 BTU PER LBM
CALORIMETER CHANNEL  7 EXHAUST ENTHALPY       114.6731000 BTU PER LBM
CALORIMETER CHANNEL  8 EXHAUST ENTHALPY       114.8751000 BTU PER LBM
CALORIMETER CHANNEL  9 EXHAUST ENTHALPY       102.3036000 BTU PER LBM
CALORIMETER CHANNEL 10 EXHAUST ENTHALPY        97.8903100 BTU PER LBM
CALORIMETER CHANNEL 11 EXHAUST ENTHALPY       106.8586000 BTU PER LBM

GOX VENTURI FLOW          .0490731 LBM PER S
GH2 VENTURI FLOW          .0532396 LBM PER S
GOX INJECTOR FLOW       13.8893000 LBM PER S
GH2 INJECTOR FLOW        2.2282770 LBM PER S
CALORIMETER CHANNEL  1 H2O FLOW        1.9805860 LBM PER S
CALORIMETER CHANNEL  2 H2O FLOW        2.0854920 LBM PER S
CALORIMETER CHANNEL  3 H2O FLOW        1.9100170 LBM PER S
CALORIMETER CHANNEL  4 H2O FLOW        2.2074770 LBM PER S
CALORIMETER CHANNEL  5 H2O FLOW        1.8970480 LBM PER S
CALORIMETER CHANNEL  6 H2O FLOW        2.0451940 LBM PER S
CALORIMETER CHANNEL  7 H2O FLOW        2.0567560 LBM PER S
CALORIMETER CHANNEL  8 H2O FLOW        2.1002510 LBM PER S
CALORIMETER CHANNEL  9 H2O FLOW        1.9051980 LBM PER S
CALORIMETER CHANNEL 10 H2O FLOW        1.9291340 LBM PER S
CALORIMETER CHANNEL 11 H2O FLOW        2.0744270 LBM PER S

THE THEORETICAL CSTAR     8024.4840000
THE CSTAR     7913.6440000
CSTAR EFFICIENCY       98.6187300
```

T = 181.0, MR:5.0 (VS. 5.7 ACTUAL)

LH2 PRESS. UPSTREAM OF THE MAIN FUEL VALVE 3737.9700000 PSIG
LH2 PRESS. DOWNSTREAM OF THE MAIN FUEL VALVE 1435.8500000 PSIG
LH2 PRESS. INLET TO THE THRUST CHAMBER COOLANT JACKET 1535.4900000 PSIG
H2 PRESS. EXHAUST FROM THE THRUST CHAMBER COOLING JACKET 1341.8800000 PSIG
H2 PRESS. INLET TO THE NOZZLE COOLING JACKET 1329.4900000 PSIG
H2 PRESS. EXHAUST FROM THE NOZZLE COOLING JACKET 1301.6800000 PSIG
H2 PRESS. EXHAUST FROM THE NOZZLE COOLING JACKET-REDUNDANT 1301.6800000PSIG
NO PRESSURE AT P8
H2 PRESS. INLET TO THE FUEL MANIFOLD 942.1300000 PSIG
GH2 PRESS. INLET TO THE OLD FUEL MANIFOLD 894.9400000 PSIG
CALORIMETER CHANNEL 11 EXHAUST PRESSURE 1574.6900000 PSIG
CALORIMETER CHANNEL 12 EXHAUST PRESSURE 1487.9500000 PSIG
CALORIMETER CHANNEL 13 EXHAUST PRESSURE 1477.9000000 PSIG
CALORIMETER CHANNEL 14 EXHAUST PRESSURE 1541.1500000 PSIG
CALORIMETER CHANNEL 15 EXHAUST PRESSURE 1546.5900000 PSIG
CALORIMETER CHANNEL 16 EXHAUST PRESSURE 1403.9600000 PSIG
CALORIMETER CHANNEL 17 EXHAUST PRESSURE 1491.8000000 PSIG
CALORIMETER CHANNEL 18 EXHAUST PRESSURE 1550.0600000 PSIG
CALORIMETER CHANNEL 19 EXHAUST PRESSURE 1459.9500000 PSIG
CALORIMETER CHANNEL 20 EXHAUST PRESSURE 1433.6600000 PSIG
CALORIMETER CHANNEL 21 EXHAUST PRESSURE 1462.5200000 PSIG
LOX PRESS. INLET TO THE MAIN OXIDIZER VALVE 2743.5800000 PSIG
LOX PRESS. EXHAUST FROM THE MAIN OXIDIZER VALVE 897.5600000 PSIG
H2O PRESS. CALORIMETER INLET MANIFOLD 3476.6200000 PSIG
GOX PRESS. INLET TO THE IGNITER VENTURI 1985.2500000 PSIG
NO PRESSURE AT P26
GH2 PRESS. INLET TO THE IGNITER VENTURI 1964.0800000 PSIG
NO PRESSURE AT P28
LOX DOME HIGH FREQUENCY PRESSURE TRANSDUCER 2560.0000000 PSIG
CHAMBER PRESSURE 820.8600000 PSIG
CHAMBER PRESSURE 822.9600000 PSIG
IGNITER PRESSURE 855.7400000 PSIG
IGNITER PRESSURE 852.6900000 PSIG
GOX PRESS. EXHAUST FROM THE IGNITER VENTURI 853.3800000 PSIG
GH2 PRESS. EXHAUST FROM THE IGNITER VENTURI 960.7400000 PSIG
H2O PRESS. CALORIMETER EXHAUST PLENUM 760.3100000 PSIG
CALORIMETER CHANNEL 1 INLET PRESSURE 2841.3800000 PSIG
CALORIMETER CHANNEL 2 INLET PRESSURE 2807.0400000 PSIG
CALORIMETER CHANNEL 3 INLET PRESSURE 2799.4300000 PSIG
CALORIMETER CHANNEL 4 INLET PRESSURE 2762.5900000 PSIG
CALORIMETER CHANNEL 5 INLET PRESSURE 2935.4000000 PSIG
CALORIMETER CHANNEL 6 INLET PRESSURE 2705.3300000 PSIG
CALORIMETER CHANNEL 7 INLET PRESSURE 2774.5700000 PSIG
CALORIMETER CHANNEL 8 INLET PRESSURE 2808.8200000 PSIG
CALORIMETER CHANNEL 9 INLET PRESSURE 2886.1300000 PSIG
CALORIMETER CHANNEL 10 INLET PRESSURE 2722.3000000 PSIG
CALORIMETER CHANNEL 11 INLET PRESSURE 2741.4100000 PSIG

LH2 TEMP. UPSTREAM OF THE MAIN FUEL VALVE -390.0000000 DEG F
LH2 TEMP. DOWNSTREAM OF THE MAIN FUEL VALVE -390.0000000 DEG F
LH2 TEMP. INLET TO THE THRUST CHAMBER COOLING JACKET -367.1300000 DEG F
H2 TEMP. EXHAUST FROM THE THRUST CHAMBER COOLING JACKET -31.6900000 DEG F
H2 TEMP. INLET TO THE NOZZLE COOLING JACKET -30.7300000 DEG F
H2 TEMP. EXHAUST FROM THE NOZZLE COOLING JACKET 111.3300000 DEG F
LOX TEMP. INLET TO THE MAIN OXIDIZER VALVE -278.6900000 DEG F
LOX TEMP. EXHAUST FROM THE MAIN OXIDIZER VALVE -278.6900000 DEG F
H2 TEMP. INLET TO THE FUEL MANIFOLD 112.1300000 DEG F
GH2 TEMP. INLET TO THE OLD FUEL MANIFOLD 79.3200000 DEG F
CALORIMETER CHANNEL 11 EXHAUST TEMP. 126.8200000 DEG F
CALORIMETER CHANNEL 12 EXHAUST TEMP. 130.4600000 DEG F
CALORIMETER CHANNEL 13 EXHAUST TEMP. 132.4600000 DEG F
CALORIMETER CHANNEL 14 EXHAUST TEMP. 135.2400000 DEG F
CALORIMETER CHANNEL 15 EXHAUST TEMP. 136.2500000 DEG F
CALORIMETER CHANNEL 16 EXHAUST TEMP. 139.8100000 DEG F
CALORIMETER CHANNEL 17 EXHAUST TEMP. 141.0100000 DEG F
CALORIMETER CHANNEL 18 EXHAUST TEMP. 140.4500000 DEG F

CALORIMETER CHANNEL 19 EXHAUST TEMP. 129.5000000 DEG F
CALORIMETER CHANNEL 20 EXHAUST TEMP. 125.5300000 DEG F
CALORIMETER CHANNEL 21 EXHAUST TEMP. 134.9100000 DEG F
GOX TEMP. INLET TO THE IGNITER VENTURI 63.7200000 DEG F
H2 TEMP. INLET TO THE IGNITER VENTURI 78.8600000 DEG F
H2O TEMP. CALORIMETER INLET MANIFOLD 64.4900000 DE G F
TEMP. MAIN OXIDIZER VALVE OPERATOR 35.3300000 DEG F
TEMP. MAIN FUEL VALVE OPERATOR 81.2000000 DEG F
H2O TEMP. CALORIMETER EXHAUST PLENUM 94.0900000 DE G F

LOX PRESS. UPSTREAM OF SYSTEM VENTURI 2774.8600000 P SIG
LOX PRESS. DOWNSTREAM OF SYSTEM VENTURI 2737.7500000 PSIG
LH2 PRESS. UPSTREAM OF SYSTEM VENTURI 3740.2500000 P SIG
LH2 PRESS. DOWNSTREAM OF SYSTEM VENTURI 3715.4400000 PSIG

LOX TEMP. UPSTREAM OF THE SYSTEM VENTURI -280.8400000 DEG F
LH2 TEMP. UPSTREAM OF THE SYSTEM VENTURI -383.0000000 DEG F

THE NOZZLE MIXTURE RATIO IS 4.5416990

THE INJECTOR MIXTURE RATIO IS 5.7178430

CORRECTED CALORIMETER CHANNEL 1 INLET PRESS. 2821.1800000 PSIG
CORRECTED CALORIMETER CHANNEL 2 INLET PRESS. 2795.6400000 PSIG
CORRECTED CALORIMETER CHANNEL 3 INLET PRESS. 2782.0300000 PSIG
CORRECTED CALORIMETER CHANNEL 4 INLET PRESS. 2744.3900000 PSIG
CORRECTED CALORIMETER CHANNEL 5 INLET PRESS. 2924.5000000 PSIG
CORRECTED CALORIMETER CHANNEL 6 INLET PRESS. 2698.7300000 PSIG
CORRECTED CALORIMETER CHANNEL 7 INLET PRESS. 2763.7700000 PSIG
CORRECTED CALORIMETER CHANNEL 8 INLET PRESS. 2796.6200000 PSIG
CORRECTED CALORIMETER CHANNEL 9 INLET PRESS. 2872.2300000 PSIG
CORRECTED CALORIMETER CHANNEL 10 INLET PRESS. 2709.5000000 PSIG
CORRECTED CALORIMETER CHANNEL 11 INLET PRESS. 2724.6100000 PSIG

CALORIMETER CHANNEL 1 EXHAUST SATURATION PRESS. 2.0429740 PSIA
CALORIMETER CHANNEL 2 EXHAUST SATURATION PRESS. 2.2527810 PSIA
CALORIMETER CHANNEL 3 EXHAUST SATURATION PRESS. 2.3757060 PSIA
CALORIMETER CHANNEL 4 EXHAUST SATURATION PRESS. 2.5560540 PSIA
CALORIMETER CHANNEL 5 EXHAUST SATURATION PRESS. 2.6244060 PSIA
CALORIMETER CHANNEL 6 EXHAUST SATURATION PRESS. 2.8778870 PSIA
CALORIMETER CHANNEL 7 EXHAUST SATURATION PRESS. 2.9679030 PSIA
CALORIMETER CHANNEL 8 EXHAUST SATURATION PRESS. 2.9256000 PSIA
CALORIMETER CHANNEL 9 EXHAUST SATURATION PRESS. 2.1957400 PSIA
CALORIMETER CHANNEL 10 EXHAUST SATURATION PRESS. 1.9727450 PSIA
CALORIMETER CHANNEL 11 EXHAUST SATURATION PRESS. 2.5340510 PSIA

THE CALORIMETER EXHAUST PLENUM SATURATION PRESSURE .7936804 PSIA

COOLANT PRESSURE DROP ACROSS THRUST CHAMBER 193.6100000 PSID
COOLANT PRESSURE DROP ACROSS NOZZLE 27.8099400 PSID
CALORIMETER CHANNEL 1 PRESSURE DROP 1246.4900000 PSID
CALORIMETER CHANNEL 2 PRESSURE DROP 1307.6900000 PSID
CALORIMETER CHANNEL 3 PRESSURE DROP 1304.1300000 PSID
CALORIMETER CHANNEL 4 PRESSURE DROP 1203.2400000 PSID
CALORIMETER CHANNEL 5 PRESSURE DROP 1377.9100000 PSID
CALORIMETER CHANNEL 6 PRESSURE DROP 1294.7700000 PSID
CALORIMETER CHANNEL 7 PRESSURE DROP 1271.9700000 PSID
CALORIMETER CHANNEL 8 PRESSURE DROP 1246.5600000 PSID
CALORIMETER CHANNEL 9 PRESSURE DROP 1412.2800000 PSID
CALORIMETER CHANNEL 10 PRESSURE DROP 1275.8400000 PSID
CALORIMETER CHANNEL 11 PRESSURE DROP 1262.0900000 PSID

COOLANT TEMP. RISE THROUGH THE THRUST CHAMBER 335.4400000 DEG F
COOLANT TEMP. RISE THROUGH THE NOZZLE 142.0600000 DEG F
CALORIMETER CHANNEL 1 TEMP. RISE 62.3299600 DEG F
CALORIMETER CHANNEL 2 TEMP. RISE 65.9699700 DEG F

CALORIMETER CHANNEL 3 TEMP. RISE 67.9699700 DEG F
CALORIMETER CHANNEL 4 TEMP. RISE 70.7500000 DEG F
CALORIMETER CHANNEL 5 TEMP. RISE 71.7600100 DEG F
CALORIMETER CHANNEL 6 TEMP. RISE 75.3199500 DEG F
CALORIMETER CHANNEL 7 TEMP. RISE 76.5199600 DEG F
CALORIMETER CHANNEL 8 TEMP. RISE 75.9599600 DEG F
CALORIMETER CHANNEL 9 TEMP. RISE 65.0100100 DEG F
CALORIMETER CHANNEL 10 TEMP. RISE 61.0399800 DEG F
CALORIMETER CHANNEL 11 TEMP. RISE 70.4199800 DEG F

THRUST CHAMBER COOLANT JACKET RESISTANCE 124.4371000 S^2 PER FT^3-IN^2
NOZZLE COOLANT JACKET RESISTANCE 3.0020760 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 1 RESISTANCE 19889.7800000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 2 RESISTANCE 18585.2600000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 3 RESISTANCE 22539.9900000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 4 RESISTANCE 15500.9800000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 5 RESISTANCE 22328.6600000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 6 RESISTANCE 19260.3700000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 7 RESISTANCE 18474.7600000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 8 RESISTANCE 17928.8100000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 9 RESISTANCE 25203.0400000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 10 RESISTANCE 21826.2300000 S^2 PER FT^3-IN^2
CALORIMETER CHANNEL 11 RESISTANCE 17850.3500000 S^2 PER FT^3-IN^2
MAIN LOX VALVE RESISTANCE 749.7332000 S^2 PER FT^3-IN^2
MAIN FUEL VALVE RESISTANCE 2190.2780000 S^2 PER FT^3-IN^2

HEAT TRANSFER TO THE H2 IN THRUST CHAMBER 2979.5490000 BTU PER S
HEAT TRANSFER TO THE H2 IN NOZZLE 1176.3400000 BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 1 115.8174000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 2 130.0022000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 3 121.6962000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 4 147.6276000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 5 132.6882000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 6 146.2643000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 7 150.5965000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 8 150.2936000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 9 113.7113000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 10 109.2904000BTU PER S
HEAT TRANSFER TO CALORIMETER CHANNEL 11 139.9007000BTU PER S

LOX DENSITY UPSTREAM OF MOV 70.7589600 LBM PER FT^3
LH2 DENSITY UPSTREAM OF MFV 4.8755100 LBM PER FT^ 3
LH2 DENSITY INLET TO T.C. COOLANT JACKET 3.2936000 LBM PER FT^3
H2 DENSITY EXHAUST FROM T.C. COOLANT JACKET .5591724 LBM PER FT^3
H2 DENSITY INLET TO NOZZLE COOLANT JACKET .5531850 LBM PER FT^3
H2 DENSITY EXHAUST FROM NOZZLE COOLANT JACKET .4111857 LBM PER FT^3
H2O DENSITY CALORIMETER INLET MANIFOLD 63.0191600 LBM PER FT^3
CALORIMETER CHANNEL 1 INLET DENSITY 62.8950600 LBM PER FT^3
CALORIMETER CHANNEL 2 INLET DENSITY 62.8901600 LBM PER FT^3
CALORIMETER CHANNEL 3 INLET DENSITY 62.8876000 LBM PER FT^3
CALORIMETER CHANNEL 4 INLET DENSITY 62.8803900 LBM PER FT^3
CALORIMETER CHANNEL 5 INLET DENSITY 62.9146700 LBM PER FT^3
CALORIMETER CHANNEL 6 INLET DENSITY 62.8716800 LBM PER FT^3
CALORIMETER CHANNEL 7 INLET DENSITY 62.8840600 LBM PER FT^3
CALORIMETER CHANNEL 8 INLET DENSITY 62.8903300 LBM PER FT^3
CALORIMETER CHANNEL 9 INLET DENSITY 62.9047500 LBM PER FT^3
CALORIMETER CHANNEL 10 INLET DENSITY 62.8737600 LBM PER FT^3
CALORIMETER CHANNEL 11 INLET DENSITY 62.8766200 LBM PER FT^3
CALORIMETER CHANNEL 1 EXHAUST DENSITY 61.8973800 LBM PER FT^3
CALORIMETER CHANNEL 2 EXHAUST DENSITY 61.8209600 LBM PER FT^3
CALORIMETER CHANNEL 3 EXHAUST DENSITY 61.7852100 LBM PER FT^3
CALORIMETER CHANNEL 4 EXHAUST DENSITY 61.7489300 LBM PER FT^3
CALORIMETER CHANNEL 5 EXHAUST DENSITY 61.7323300 LBM PER FT^3
CALORIMETER CHANNEL 6 EXHAUST DENSITY 61.6432600 LBM PER FT^3
CALORIMETER CHANNEL 7 EXHAUST DENSITY 61.6379400 LBM PER FT^3
CALORIMETER CHANNEL 8 EXHAUST DENSITY 61.6586800 LBM PER FT^3

CALORIMETER CHANNEL 9 EXHAUST DENSITY 61.8319100 LBM PER FT^3
CALORIMETER CHANNEL 10 EXHAUST DENSITY 61.8926600 LBM PER FT^3
CALORIMETER CHANNEL 11 EXHAUST DENSITY 61.7402400 LBM PER FT^3

GH2 ENTHALPY INLET TO T.C. COOLANT JACKET 94.9796900 BTU PER LBM
GH2 ENTHALPY EXHAUST FROM T.C. COOLANT JACKET 1411.1930000 BTU PER LBM
GH2 ENTHALPY INLET TO NOZZLE COOLANT JACKET 1414.7050000 BTU PER LBM
GH2 ENTHALPY EXHAUST FROM NOZZLE COOLANT JACKET 1934.3520000 BTU PER LBM
CALORIMETER CHANNEL 1 INLET ENTHALPY 40.4776000 BTU PER LBM
CALORIMETER CHANNEL 2 INLET ENTHALPY 40.4073800 BTU PER LBM
CALORIMETER CHANNEL 3 INLET ENTHALPY 40.3698800 BTU PER LBM
CALORIMETER CHANNEL 4 INLET ENTHALPY 40.2659800 BTU PER LBM
CALORIMETER CHANNEL 5 INLET ENTHALPY 40.7629600 BTU PER LBM
CALORIMETER CHANNEL 6 INLET ENTHALPY 40.1400700 BTU PER LBM
CALORIMETER CHANNEL 7 INLET ENTHALPY 40.3194500 BTU PER LBM
CALORIMETER CHANNEL 8 INLET ENTHALPY 40.4101000 BTU PER LBM
CALORIMETER CHANNEL 9 INLET ENTHALPY 40.6185600 BTU PER LBM
CALORIMETER CHANNEL 10 INLET ENTHALPY 40.1686900 BTU PER LBM
CALORIMETER CHANNEL 11 INLET ENTHALPY 40.2110600 BTU PER LBM
CALORIMETER CHANNEL 1 EXHAUST ENTHALPY 98.8135500 BTU PER LBM
CALORIMETER CHANNEL 2 EXHAUST ENTHALPY 102.2078000 BTU PER LBM
CALORIMETER CHANNEL 3 EXHAUST ENTHALPY 104.1684000 BTU PER LBM
CALORIMETER CHANNEL 4 EXHAUST ENTHALPY 107.0871000 BTU PER LBM
CALORIMETER CHANNEL 5 EXHAUST ENTHALPY 108.1036000 BTU PER LBM
CALORIMETER CHANNEL 6 EXHAUST ENTHALPY 111.2855000 BTU PER LBM
CALORIMETER CHANNEL 7 EXHAUST ENTHALPY 112.6956000 BTU PER LBM
CALORIMETER CHANNEL 8 EXHAUST ENTHALPY 112.2834000 BTU PER LBM
CALORIMETER CHANNEL 9 EXHAUST ENTHALPY 101.1844000 BTU PER LBM
CALORIMETER CHANNEL 10 EXHAUST ENTHALPY 97.1770800 BTU PER LBM
CALORIMETER CHANNEL 11 EXHAUST ENTHALPY 106.5630000 BTU PER LBM

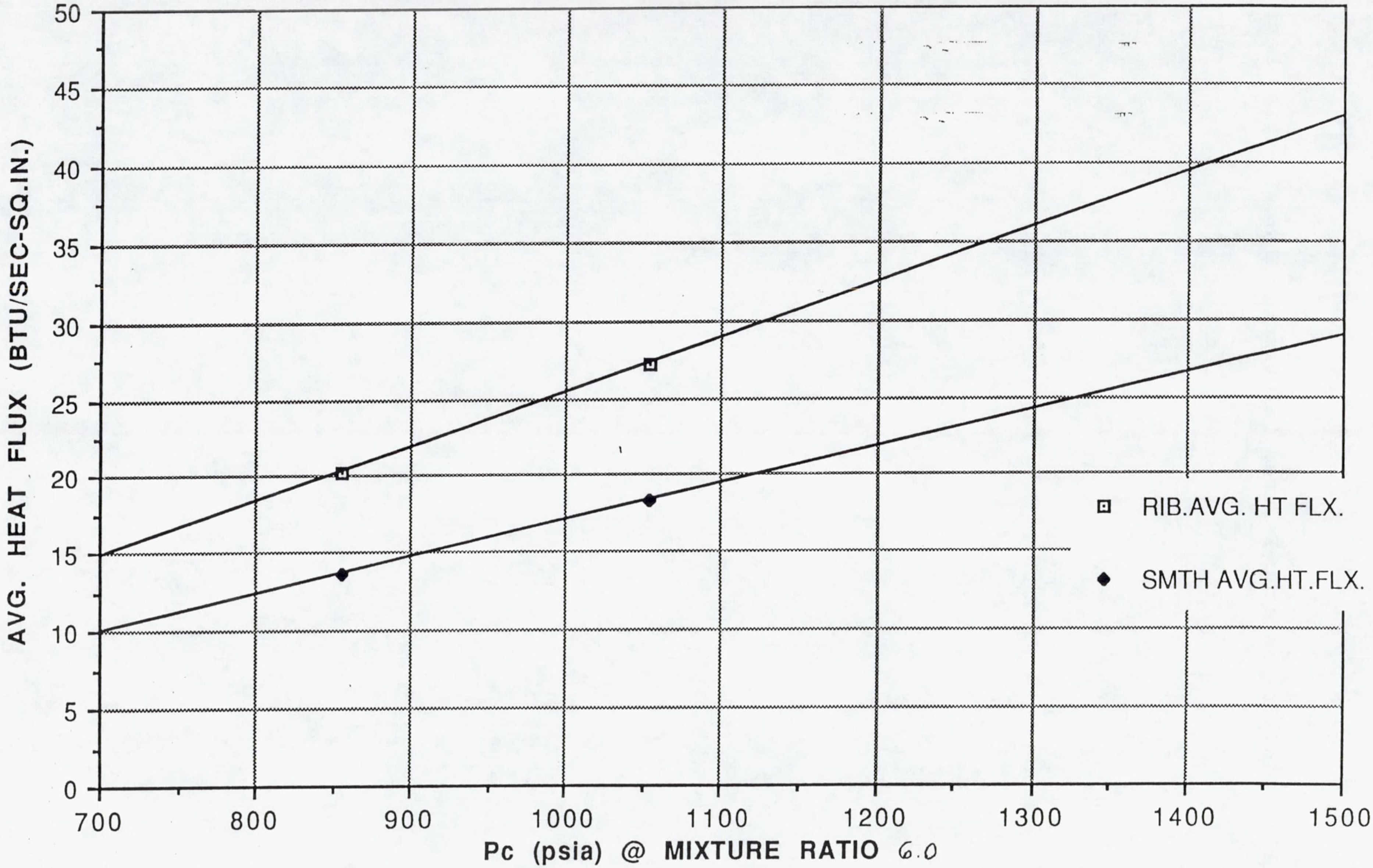
GOX VENTURI FLOW .0482893 LBM PER S
GH2 VENTURI FLOW .0531819 LBM PER S
GOX INJECTOR FLOW 13.1994400 LBM PER S
GH2 INJECTOR FLOW 2.2637290 LBM PER S
CALORIMETER CHANNEL 1 H2O FLOW 1.9853530 LBM PER S
CALORIMETER CHANNEL 2 H2O FLOW 2.1035820 LBM PER S
CALORIMETER CHANNEL 3 H2O FLOW 1.9075070 LBM PER S
CALORIMETER CHANNEL 4 H2O FLOW 2.2092970 LBM PER S
CALORIMETER CHANNEL 5 H2O FLOW 1.9704030 LBM PER S
CALORIMETER CHANNEL 6 H2O FLOW 2.0558510 LBM PER S
CALORIMETER CHANNEL 7 H2O FLOW 2.0807470 LBM PER S
CALORIMETER CHANNEL 8 H2O FLOW 2.0910900 LBM PER S
CALORIMETER CHANNEL 9 H2O FLOW 1.8774820 LBM PER S
CALORIMETER CHANNEL 10 H2O FLOW 1.9170940 LBM PER S
CALORIMETER CHANNEL 11 H2O FLOW 2.1084650 LBM PER S

THE THEORETICAL CSTAR 8101.2440000
THE CSTAR 7926.5510000
CSTAR EFFICIENCY 97.8436200

APPENDIX IV

IV. Plots and Graphs from Reduced Calorimeter Heat Transfer Data

15k lbf INTEGRATED COMPONENT EVALUATOR (I.C.E.)
0.040 IN. RIB CALORIMETER HOT-FIRE TEST DATA



APPENDIX V

V. List of Drawings

7R0016273, Layout - Calorimeter Insert, Expander Cycle Combustion Chamber

7R0016274, Housing - Calorimeter Insert, Expander Cycle Combustion Chamber

7R0016275, Liner - Calorimeter Insert, Expander Cycle Combustion Chamber

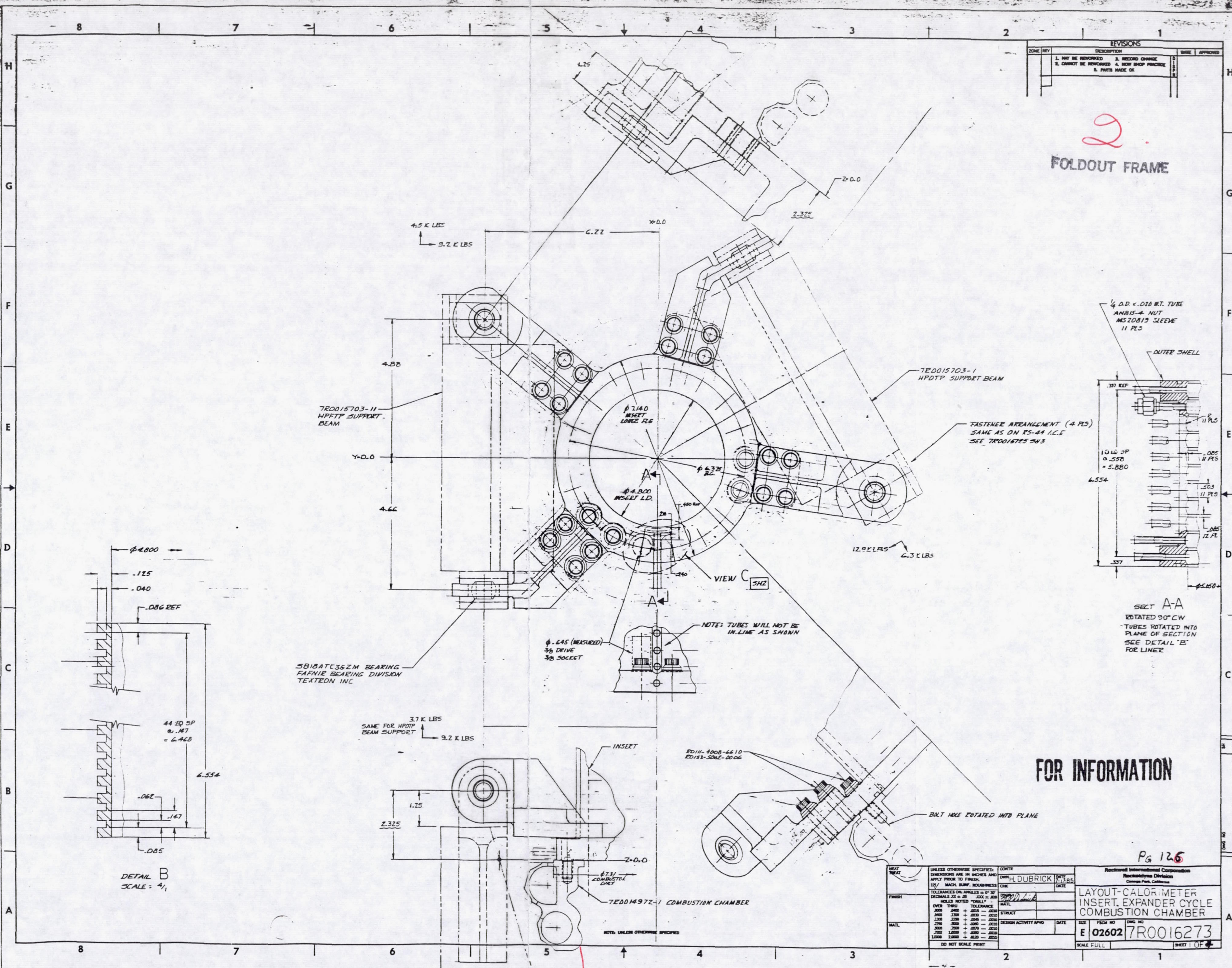
7R0016276, Liner - Calorimeter Insert, Expander Cycle Combustion Chamber

7R0016277, Insert - Calorimeter, Expander Cycle Combustion Chamber, Assy. of

7R0016278, Insert - Calorimeter Insert, Expander Cycle Combustion Chamber, Assy. of

7R0016279, Fuel Manifold - Expander Cycle Combustion Chamber, Assy. of

FOLDOUT FRAME 1.



FOLDOUT FRAME 2.

FOR INFORMATION

PG 126

HEAT TREAT	UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES AND APPLY PRIOR TO FINISH. 125/ MACH. SURF. ROUGHNESS	CONTR / DWN H. DUBRICK DATE 7-17-85 / CHK DATE	Rockwell International Corporation, Rocketdyne Division, Canoga Park, California
FINISH	TOLERANCES ON: ANGLES ± 0° 30' DECIMALS .XX ± .03 .XXX ± .010	DSGN / MATL / STRUCT	LAYOUT-CALORIMETER INSERT. EXPANDER CYCLE COMBUSTION CHAMBER
MATL	HOLES NOTED "DRILL"	DESIGN ACTIVITY APVD DATE	SIZE E FSCM NO 02602 DWG NO 7R0016273
	DO NOT SCALE PRINT		SCALE FULL SHEET 1 OF 4

OVER	THRU	TOLERANCE
.0000	.0400	+ .0015 — .0010
.0400	.1300	+ .0030 — .0010
.1300	.2290	+ .0045 — .0010
.2290	.5000	+ .0060 — .0010
.5000	.7500	+ .0070 — .0010
.7500	1.0000	+ .0090 — .0010
1.0000	2.0000	+ .0120 — .0010

NOTE: UNLESS OTHERWISE SPECIFIED

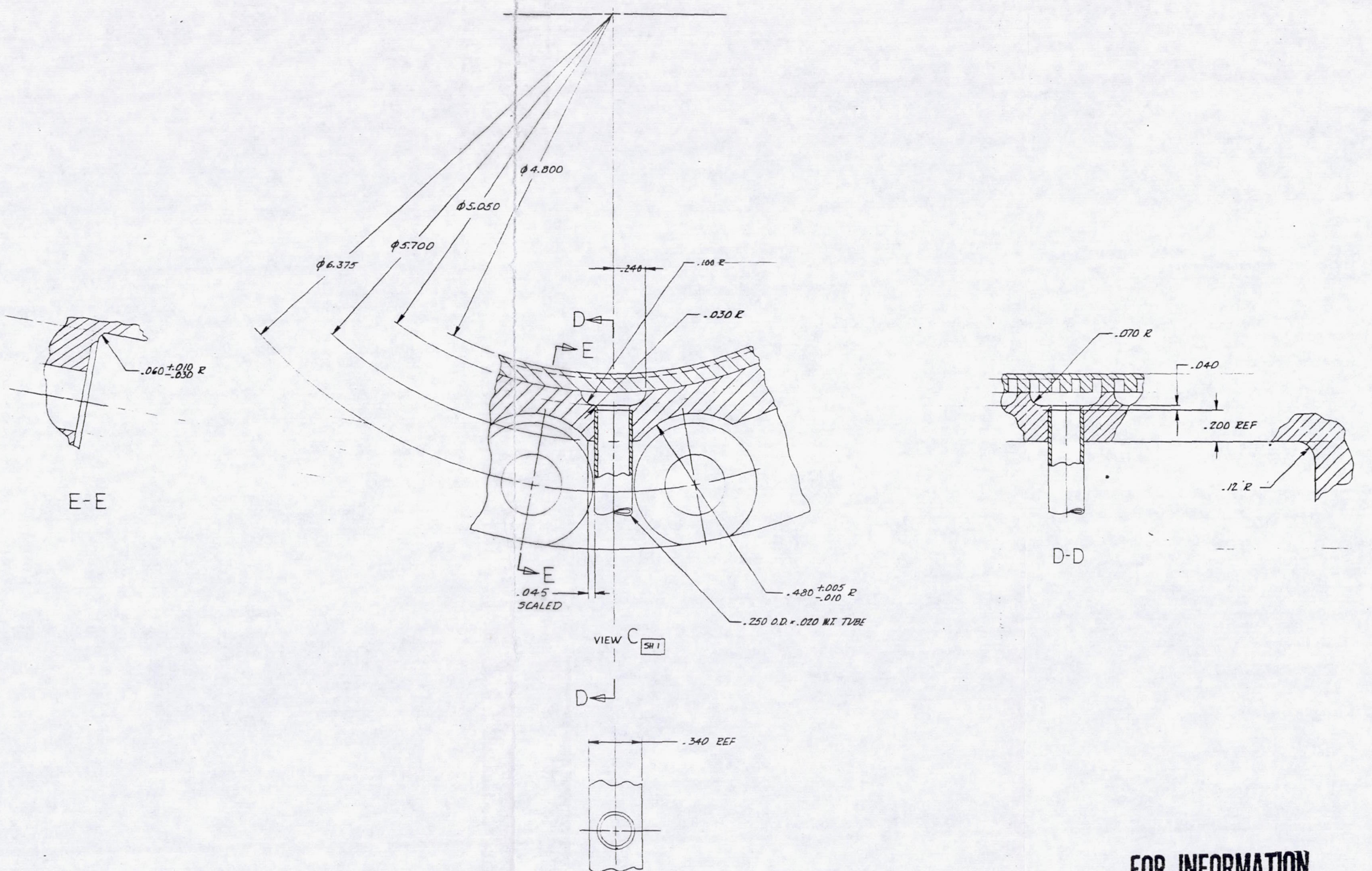
1.

FOLDOUT FRAME

2.

FOLDOUT FRAME

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED
		1. MAY BE REWORKED 2. CANNOT BE REWORKED 3. RECORD CHANGE 4. NOW SHOP PRACTICE 5. PARTS MADE OK — DISPN		



FOR INFORMATION

PG 128

Rockwell International Corporation Rocketdyne Division Canoga Park, California	SIZE E	FSCM NO 02602	DWG NO 7R0016273
DWN H. DUBRICK	DATE 8/21/85	SCALE 4/1	SHEET 2

1.

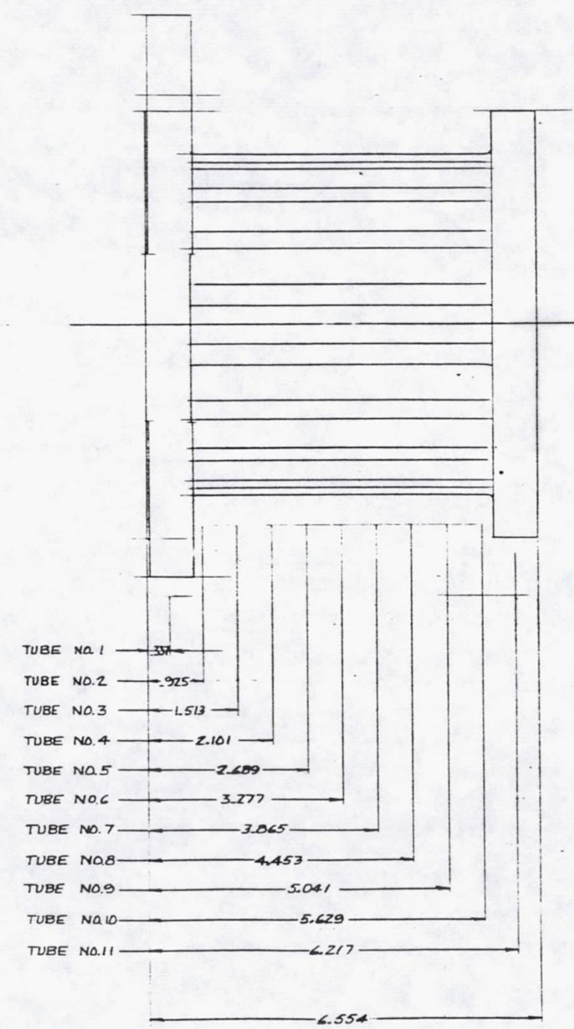
FOLDOUT FRAME

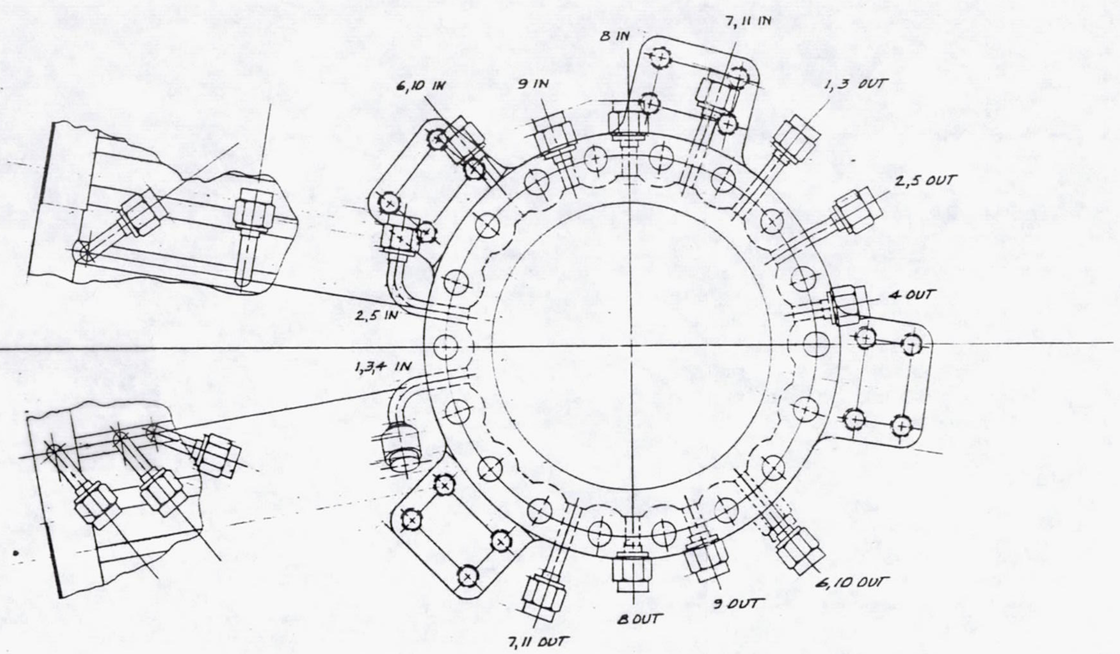
2.

FOLDOUT FRAME

REVISIONS

ZONE	REV	DESCRIPTION	DISP N	DATE	APPROVED
		1. MAY BE REWORKED 3. RECORD CHANGE 2. CANNOT BE REWORKED 4. NOW SHOP PRACTICE 5. PARTS MADE OK			





FOR INFORMATION

PG 128

NOTE: UNLESS OTHERWISE SPECIFIED

Rockwell International Corporation Rocketdyne Division Canoga Park, California	SIZE E	FSCM NO 02602	DWG NO 7R0016273
DWN H. DUBRICK	DATE 8/24/85	SCALE FULL	SHEET 3

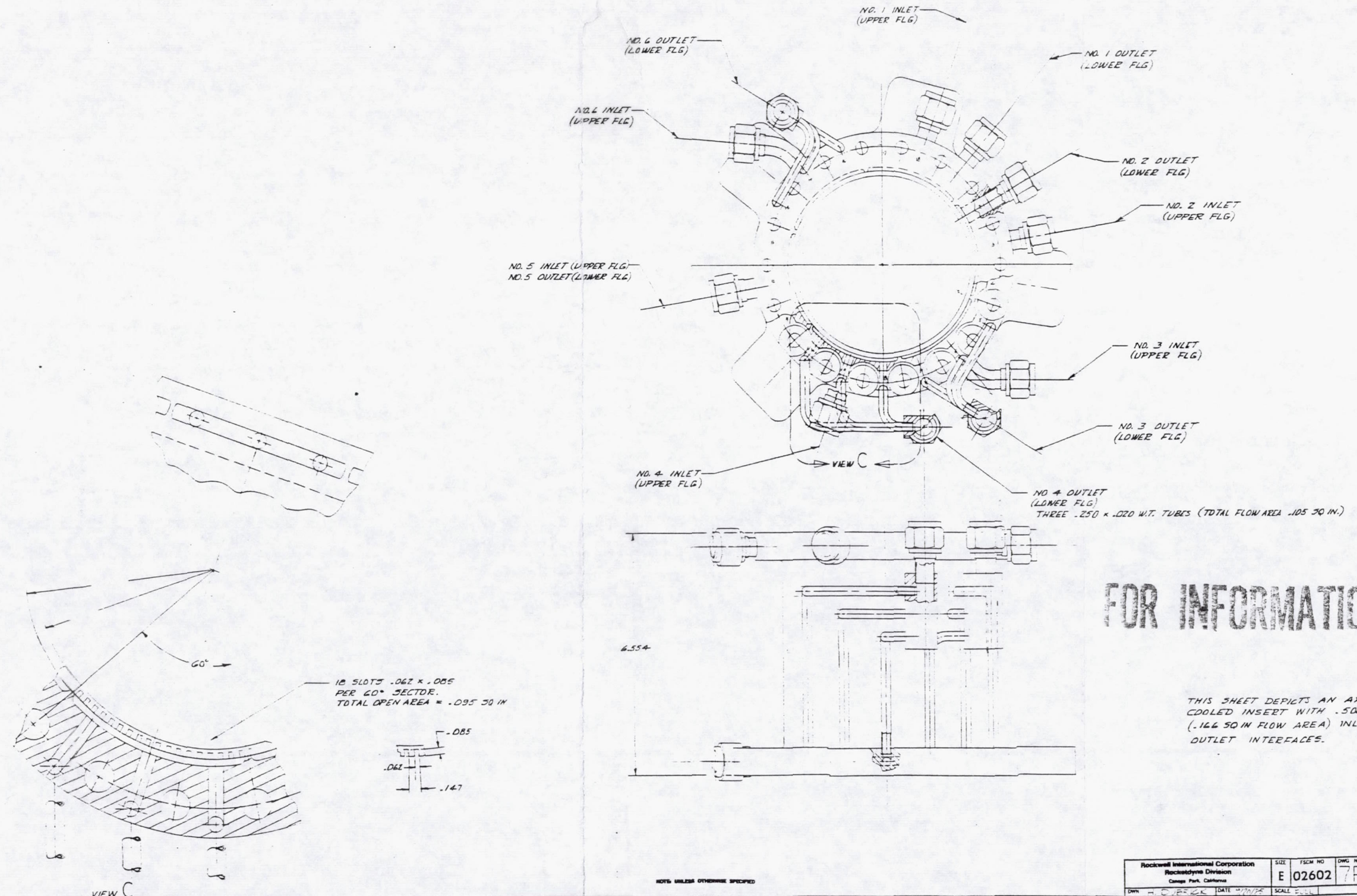
1.

FOLDOUT FRAME

2.

FOLDOUT FRAME

ZONE	REV	DESCRIPTION	DATE	APPROVED
		1. MAY BE REWORKED 3. RECORD CHANGE 2. CANNOT BE REWORKED 4. NOW SHOP PRACTICE 5. PARTS MADE OK (DISPN)		



FOR INFORMATION

THIS SHEET DEPICTS AN AXIAL FLOW COOLED INSERT WITH .500 DIA × .020 W.T. (.166 SQ IN FLOW AREA) INLET AND OUTLET INTERFACES.

NOTE: UNLESS OTHERWISE SPECIFIED

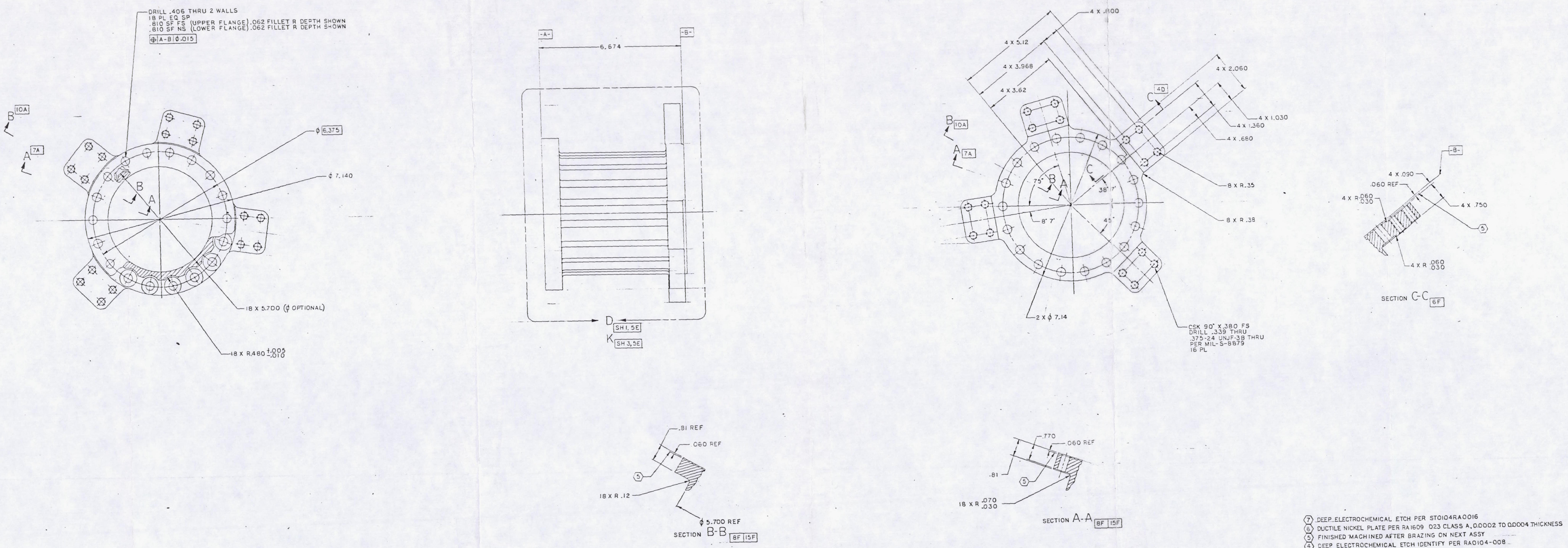
PG 129

Rockwell International Corporation Rocketdyne Division Canoga Park, California	SIZE E	FSCM NO 02602	DWG NO 7RC016273
DWN H. DUERICK	DATE 2/20/75	SCALE FULL	SHEET 2

FOLDOUT FRAME 2

FOLDOUT FRAME 3.

FOLDOUT FRAME 4.



INFORMAT

NO	MATERIAL	SIZE
-5	ALLOY 625 BAR	
-3	ALLOY 625 BAR	

7. DEEP ELECTROCHEMICAL ETCH PER ST0104RA0016
6. DUCTILE NICKEL PLATE PER RA1609 023 CLASS A, 0.0002 TO 0.0004 THICKNESS
5. FINISHED MACHINED AFTER BRAZING ON NEXT ASSY
4. DEEP ELECTROCHEMICAL ETCH IDENTIFY PER RA0104-008
3. CLEAN PER RA0110-018
2. PENETRANT INSPECT PER RA0115-116
1. MACHINE PER RA0103-002

NOTE: UNLESS OTHERWISE SPECIFIED

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES AND APPLY PRIOR TO FINISH.
DO NOT SCALE PRINT

CONTR 95285
DWN H. DUBRICK
DSGN CUBRICK R. BAILY

HOUSIN
INSERT
COMBUS

SIZE J FSCM NO 0260

Rockwell International Corporation
Rocketdyne Division

7R0016274 1

Rockwell International Corporation
Rocketdyne Division

7R0016274 1

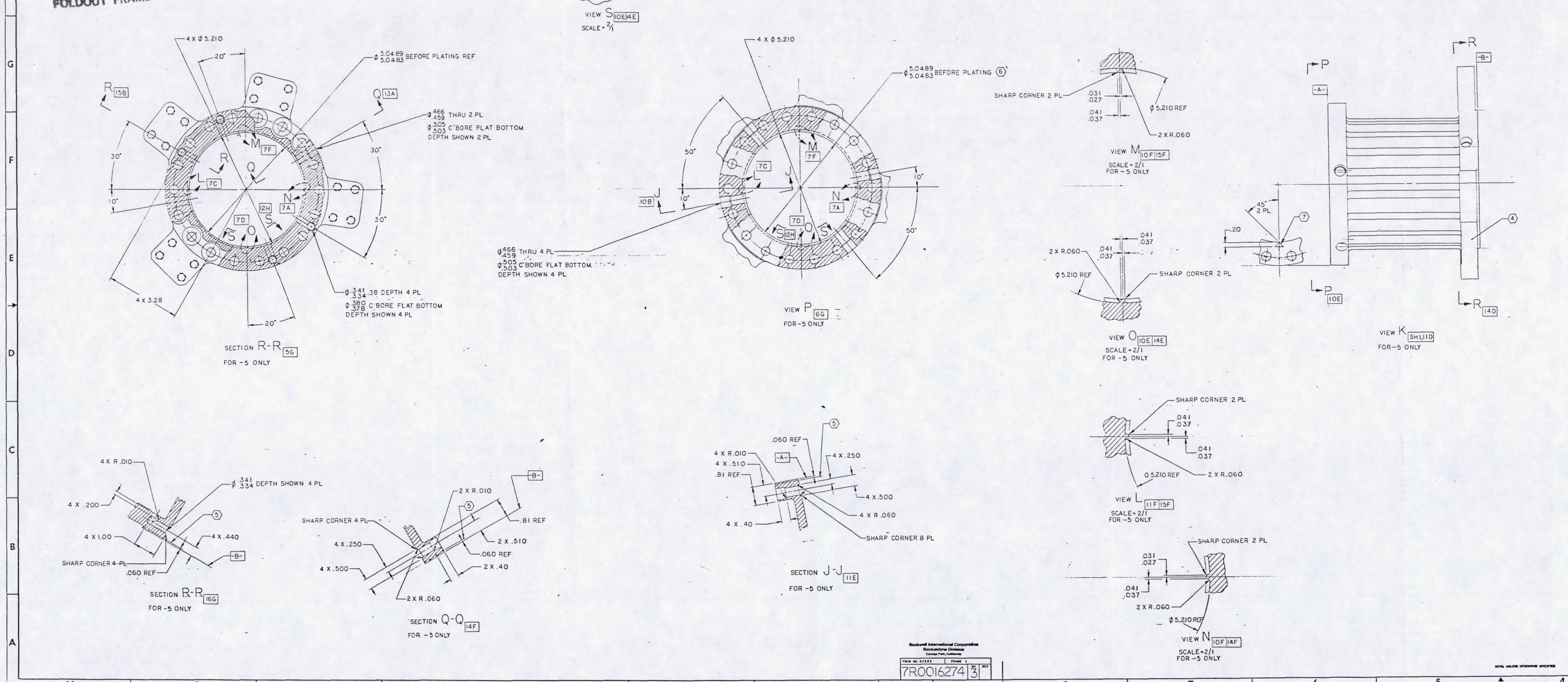
HOLE NO	'X' DEG
2 IN	10
2 OUT	150
3 IN	350
3 OUT	130
4 IN	350
4 OUT	170
5 IN	10
5 OUT	150
6 IN	50
6 OUT	230
7 IN	110
7 OUT	290
8 IN	90
8 OUT	270
9 IN	70
9 OUT	250
10 IN	50
10 OUT	230

SEE VIEW E ZONE 5B FOR AXIAL LOCATION OF HOLES

1. FOLDOUT FRAME

2. FOLDOUT FRAME

3. FOLDOUT FRAME



INFORMATION ONLY

PG 132

Rockwell International Corporation
Rocketdyne Division

7R0016274

J 02602 7R0016274

1.

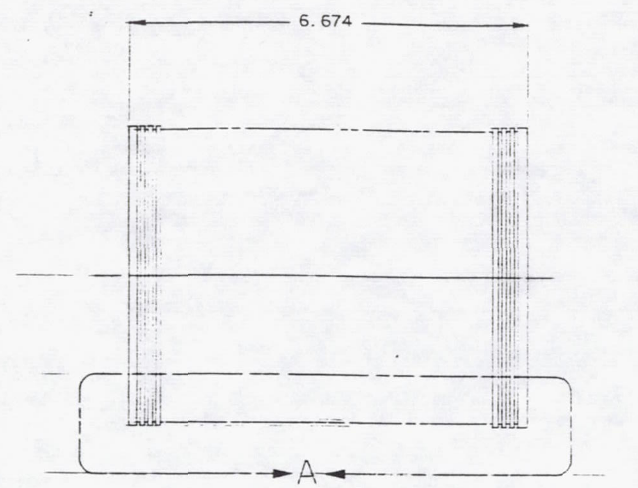
FOLDOUT FRAME

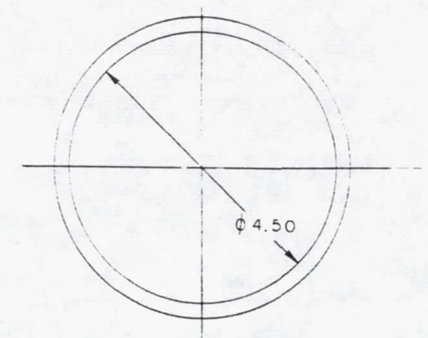
2.

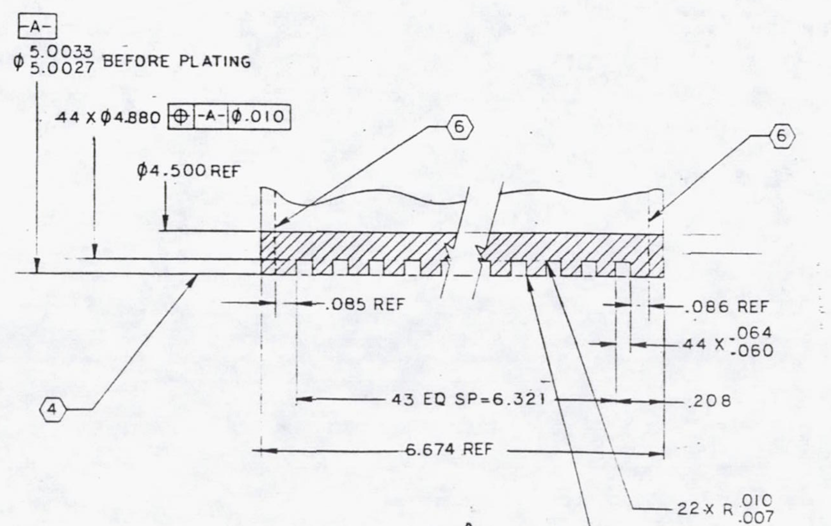
FOLDOUT FRAME

REVISIONS

ZONE	REV	DESCRIPTION	DATE	APPROVED
		1. MAY BE REWORKED 3. RECORD CHANGE 2. CANNOT BE REWORKED 4. NOW SHOP PRACTICE 5. PARTS MADE OK		







VIEW A
SCALE- 4/1

INFORMATION ONLY

-3	OFHC COPPER		COMMERCIAL GRADE
NO	MATERIAL	SIZE	SPECIFICATION

6 FINISHED MACHINED AFTER BRAZING ON NEXT ASSY
5 TAG IDENTIFY PER RA0104-008
4 GOLD PLATE PER RA0109-007 TYPE I, 0.0004 TO 0.0006 THICKNESS
3 CLEAN PER RA0110-018
2 PENETRANT INSPECT PER RA0115-116
1 MACHINE PER RA0103-002

NOTE: UNLESS OTHERWISE SPECIFIED

PG 133

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES AND APPLY PRIOR TO FINISH.
125/ MACH. SURF. ROUGHNESS
TOLERANCES ON: ANGLES ± 0° 30′
DECIMALS .XX ± .03 .XXX ± .010

HOLES NOTED "DRILL"

OVER	THRU	TOLERANCE
.0000	.0400	+ .0015 — .0010
.0400	.1300	+ .0030 — .0010
.1300	.2290	+ .0045 — .0010
.2290	.5000	+ .0060 — .0010
.5000	.7500	+ .0070 — .0010
.7500	1.0000	+ .0090 — .0010
1.0000	2.0000	+ .0120 — .0010

DO NOT SCALE PRINT

HEAT TREAT
FINISH
MATL

CONTR 95285
DRN H. DUBRICK DATE
CHK DATE
DSGN H. DUBRICK R. BAILY
MATL
STRUCT
DESIGN ACTIVITY APVD G. LOBERG DATE

Rockwell International Corporation
Rocketdyne Division
Canoga Park, California

LINER-CALORIMETER, EXPANDER CYCLE COMBUSTION CHAMBER

SIZE E FSCM NO 02602 DWG NO 7R0016275
SCALE FULL SHEET

DWG NO 7R0016275

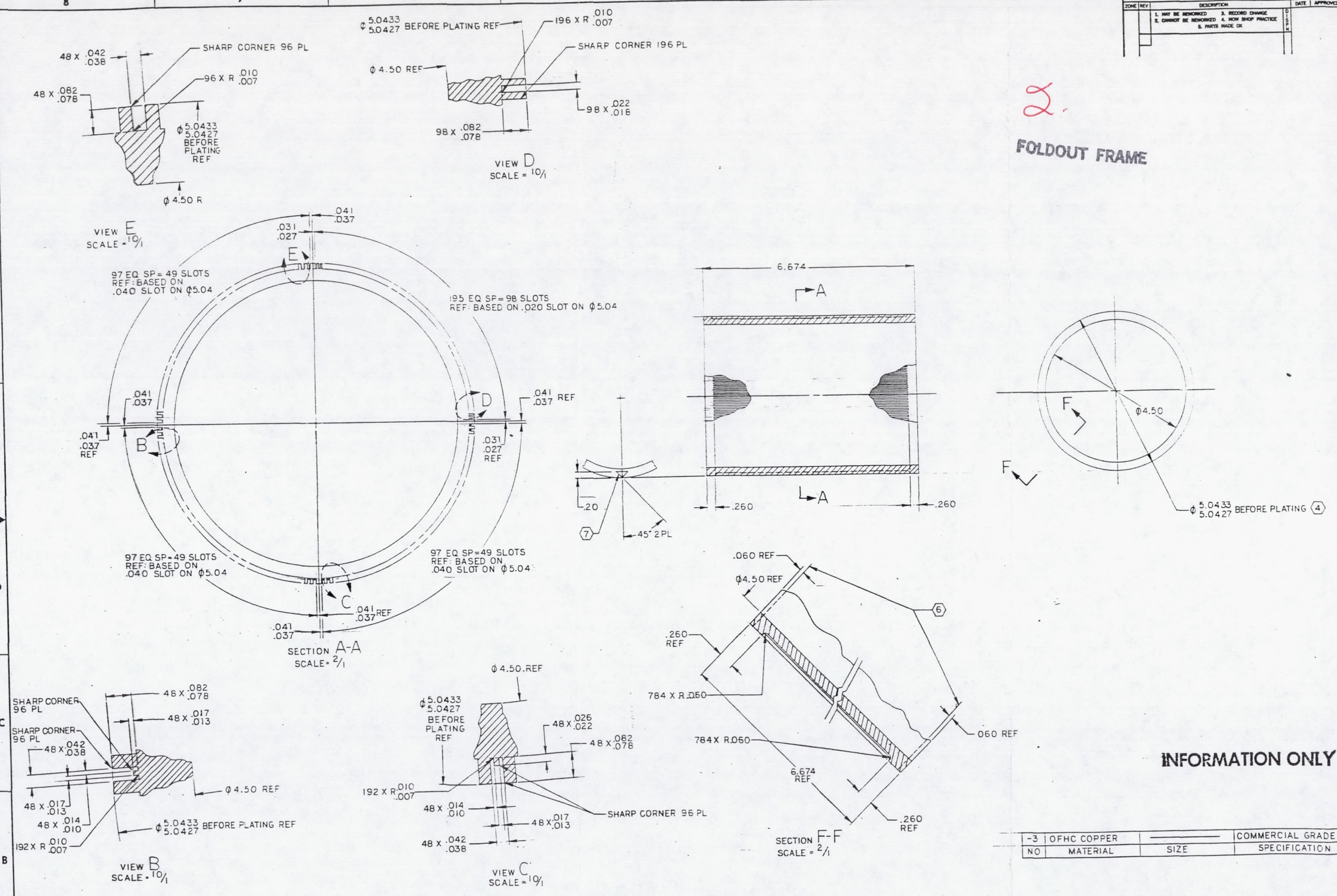
1.

FOLDOUT FRAME

2.

FOLDOUT FRAME

REVISIONS				
ZONE	REV	DESCRIPTION	DATE	APPROVED
		1. MAY BE REWORKED 2. CANNOT BE REWORKED 3. RECORD CHANGE 4. NEW SHOP PRACTICE 5. PARTS MADE OK		



INFORMATION ONLY

NO	MATERIAL	SIZE	SPECIFICATION
-3	OFHC COPPER		COMMERCIAL GRADE

7 DEEP ELECTROCHEMICAL ETCH PER ST0104RA0016
6 FINISHED MACHINED AFTER BRAZING ON NEXT ASSY
5 TAG IDENTIFY PER RA0104-008
4 GOLD PLATE PER RA0109-007 TYPE I, 0.0004 TO 0.0006 THICKNESS
3 CLEAN PER RA0110-018
2 PENETRANT INSPECT PER RA0115-116
1 MACHINE PER RA0103-002
NOTE: UNLESS OTHERWISE SPECIFIED

PG 134

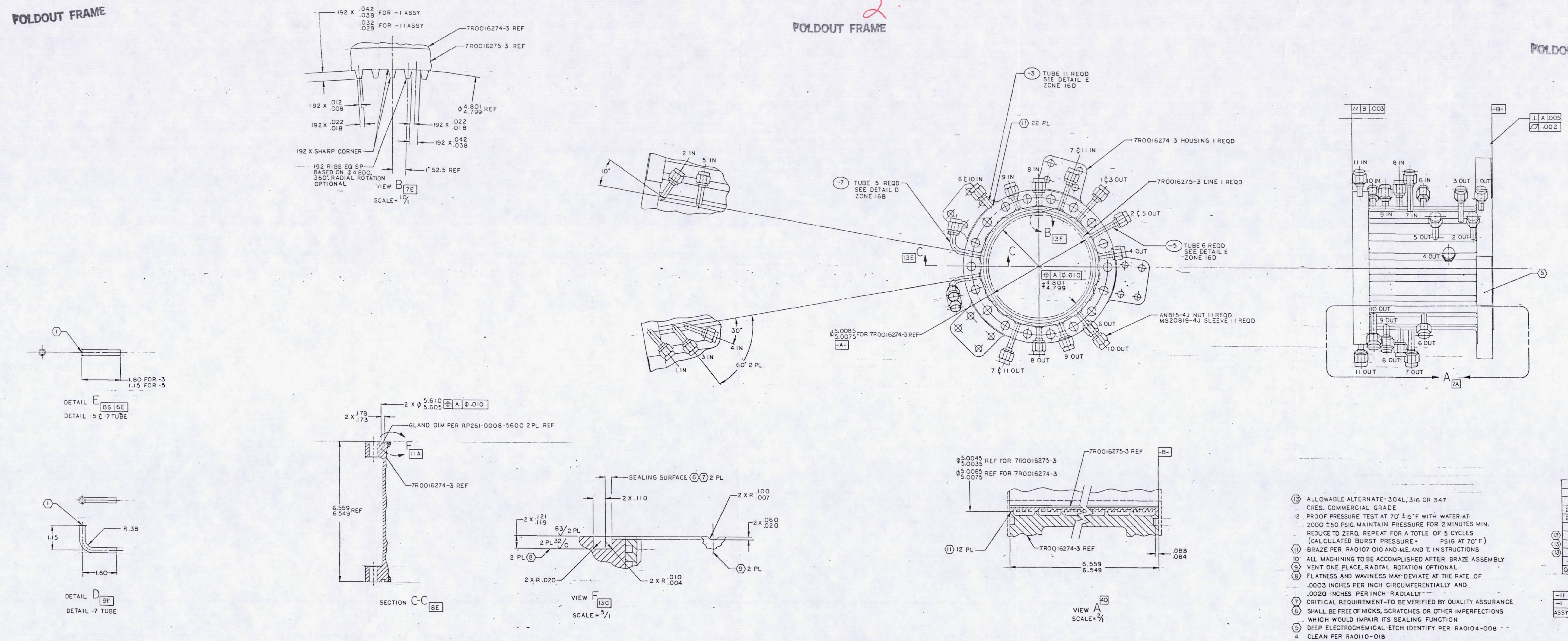
UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES AND APPLY PRIOR TO FINISH. 125/ MACH. SURF. ROUGHNESS
TOLERANCES ON: ANGLES ± 0° 30' DECIMALS .XX ± .03 .XXX ± .010
DO NOT SCALE PRINT

CONTR 95285
DWN H. DUBRICK
DSGN H. DUBRICK R. BAILY
DESIGN ACTIVITY APVD G. LOBERG

Rockwell International Corporation
Rocketdyne Division
Canoga Park, California

LINER - CALORIMETER, EXPANDER CYCLE COMBUSTION CHAMBER

SIZE E FSCM NO 02602 DWG NO 7R0016276
SCALE FULL



13. ALLOWABLE ALTERNATE: 304L, 316 OR 347 CRES. COMMERCIAL GRADE
12. PROOF PRESSURE TEST AT 70° ±15°F WITH WATER AT 2000 ±50 PSIG. MAINTAIN PRESSURE FOR 2 MINUTES MIN. REDUCE TO ZERO. REPEAT FOR A TOTLE OF 5 CYCLES (CALCULATED BURST PRESSURE = PSIG AT 70°F)
11. BRAZE PER RA0107 010 AND M.E. AND T. INSTRUCTIONS
10. ALL MACHINING TO BE ACCOMPLISHED AFTER BRAZE ASSEMBLY
9. VENT ONE PLACE. RADTAL ROTATION OPTIONAL
8. FLATNESS AND WAVINESS MAY DEVIATE AT THE RATE OF .0003 INCHES PER INCH CIRCUMFERENTIALLY AND .0020 INCHES PER INCH RADIALLY
7. CRITICAL REQUIREMENT-TO BE VERIFIED BY QUALITY ASSURANCE
6. SHALL BE FREE OF NICKS, SCRATCHES OR OTHER IMPERFECTIONS WHICH WOULD IMPAIR ITS SEALING FUNCTION
5. DEEP ELECTROCHEMICAL ETCH IDENTIFY PER RA0104-008
4. CLEAN PER RA0110-018
3. MACHINE PER RA0103-002
2. INSTALL FITTINGS AND TUBE ASSEMBLIES PER RA0102-005
1. FABRICATE TUBING PER RA0102-003

NOTE: UNLESS OTHERWISE SPECIFIED

INFORMATION ONLY

	-11	-1	PART NO.	DESCRIPTION	SIZE	SPECIFICATION
	1	1	7R0016275-3	LINER		
	1	1	7R0016274-3	HOUSING		
	22		MS20819-4J	SLEEVE		
	22		AN815-4J	NUT		
13	5	5	-7	304 CRES TUBE	.250 OD X .020 W.T.	MIL-T-8504 COMP 304 SMLS
13	6	6	-5	304 CRES TUBE	.250 OD X .020 W.T.	MIL-T-8504 COMP 304 SMLS
13	11	11	-3	304 CRES TUBE	.250 O.D. X .020 W.T.	MIL-T-8504 COMP 304 SMLS
	QTY REQD		PARTS LIST			

-11
-1
ASSY

PG 135

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES AND APPLY PRIOR TO FINISH. 125/ MACH. SURF. ROUGHNESS

DO NOT SCALE PRINT

CONTR 95285
DWN H. DUBRICK
DSGN DUBRICK R. BAILY
DESIGN ACTIVITY APVD G. LOBERG

Rockwell International Corporation
Rocketdyne Division
Canoga Park, California

INSERT-CALORIMETER, EXPANDER CYCLE COMB CHAMBER, ASSY OF

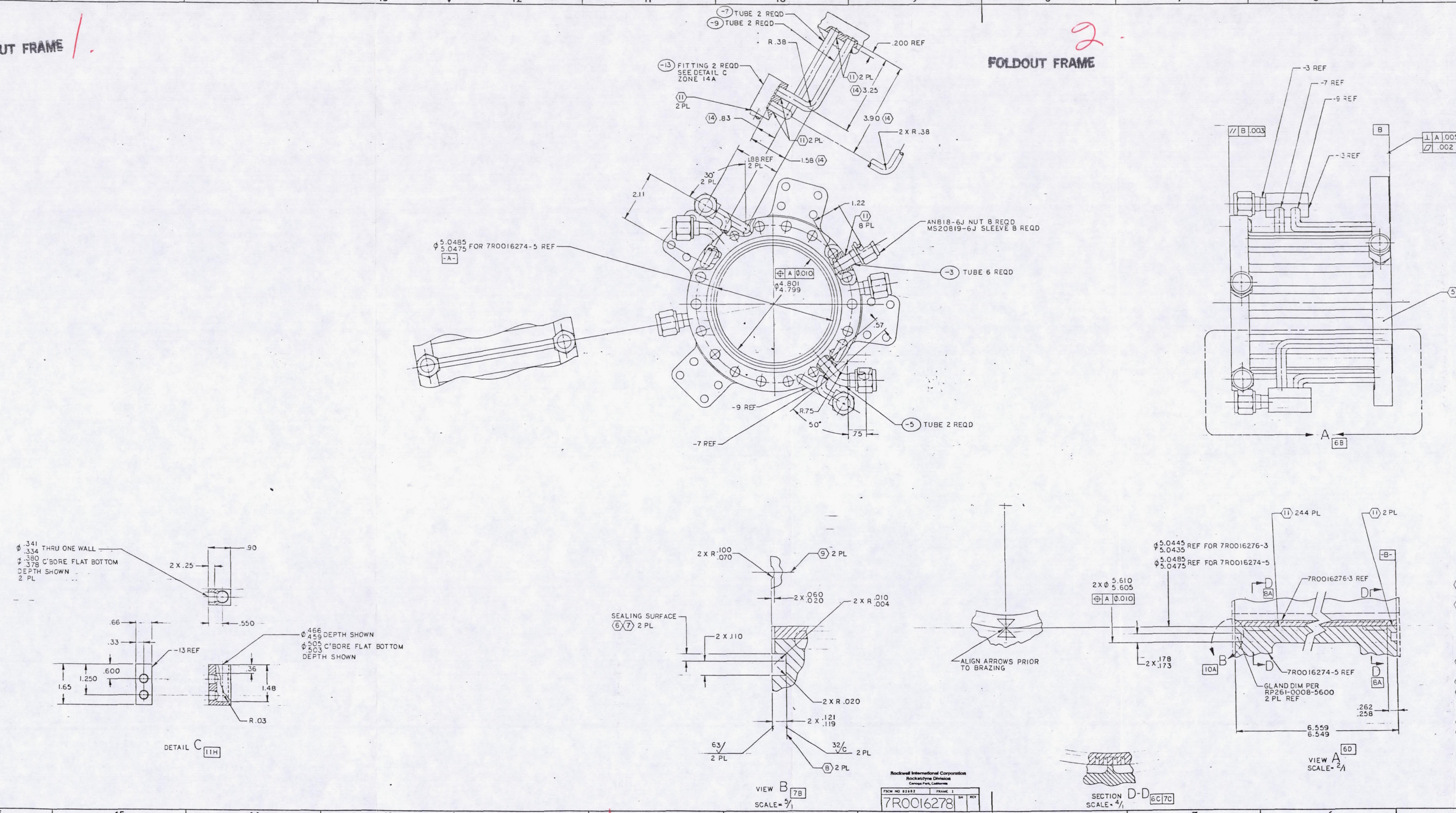
SIZE J FSCM NO 02602 DWG NO 7R0016277
SCALE FULL
FRAME 2

FORM NO. R130-N-8 REV. 7-77

FOLDOUT FRAME 1.

FOLDOUT FRAME 2.

FOLDOUT FRAME 3.



INFORMATION ONLY

14. ALLOW .25 MIN EXTRA TRIM STOCK. TRIM AT ASSY TO ASSURE PROPER FIT
13. ALLOWABLE ALTERNATE: 304L, 316 OR 347 CRES. COMMERCIAL GRADE
12. PROOF PRESSURE TEST AT 70° ± 15°F WITH WATER AT 2000 ± 50 PSIG. MAINTAIN PRESSURE FOR 2 MINUTES MIN. REDUCE TO ZERO. REPEAT FOR A TOTAL OF 5 CYCLES. (CALCULATED BURST PRESSURE- PSIG AT 70°F)
11. BRAZE PER RA0107-010 AND M.E. AND T. INSTRUCTIONS
10. ALL MACHINING TO BE ACCOMPLISHED AFTER BRAZE ASSEMBLY
9. VENT ONE PLACE. RADIAL ROTATION OPTIONAL
8. FLATNESS AND WAVINESS MAY DEVIATE AT THE RATE OF .0003 INCHES PER INCH CIRCUMFERENTIALLY AND .0020 INCHES PER INCH RADIALLY
7. CRITICAL REQUIREMENT-TO BE VERIFIED BY QUALITY ASSURANCE
6. SHALL BE FREE OF NICKS, SCRATCHES OR OTHER IMPERFECTIONS WHICH WOULD IMPAIR ITS SEALING FUNCTION
5. DEEP ELECTROCHEMICAL ETCH IDENTIFY PER RA0104-008
4. CLEAN PER RA0110-018
3. MACHINE PER RA0103-002
2. INSTALL FITTINGS AND TUBE ASSEMBLIES PER RA0102-005
1. FABRICATE TUBING PER RA0102-003

NOTE: UNLESS OTHERWISE SPECIFIED

	1	7R0016276-3	LINER		
	1	7R0016274-5	HOUSING		
	6	MS20819-8J	SLEEVE		
	6	AN815-8J	NUT		
13	2	-13	304 CRES BAR		COMMERCIAL GRADE
13	2	-9	304 CRES TUBE	.375 O.D. X .020 W.T.	COMMERCIAL GRADE SMLS
13	2	-7		.375 O.D. X .020 W.T.	
13	2	-5		.500 OD X .020 W.T.	
13	6	-3	304 CRES TUBE	.500 O.D. X .020 W.T.	COMMERCIAL GRADE SMLS
	-1	PART NO	DESCRIPTION	SIZE	SPECIFICATION
	QTY	PARTS LIST			

-1 ASSY

PG 136

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN INCHES AND APPLY PRIOR TO FINISH. 125/ MACH. SURF. ROUGHNESS. DO NOT SCALE PRINT

CONTR 95285
DWN H. DUBRICK
DSGN H. DUBRICK R. BAILY
DESIGN ACTIVITY APVD G. LOBERG

Rockwell International Corporation
Rocketdyne Division
Canoga Park, California

INSERT - CALORIMETER, EXPANDER CYCLE COMB CHAMBER, ASSY OF

SIZE J FSCM NO 02602 DWG NO 7R0016278
SCALE FULL

FRAME 2

FORM NO. R130-N-4 REV. 7-77


FOLDOUT FRAME 1.
2. FOLDOUT FRAME
3. FOLDOUT FRAME
7R0016778-3 PORT 1 REQD
RD273-6004-0002 PLUG 1 REQD
RE261-3005-1002 SEAL 1 REQD
TORQUE 95±5 IN-LBS
CSK 120° X .380 NS FS
DRILL .339 X .75 DEEP
.375-24UNJF-3B
PER MIL S 8879
.500 MIN FULL THREAD
2 THREADED HOLES IN LINE
18 PL EQ SP
-3 MANIFOLD 1 REQD
36 X FULL R
18 X .400
SLOT 18 PL EQ SP
VIEW B-B
36 X R .12
ϕ6.375
VIEW A
SCALE 4/1
7R0014972-25 SHELL 1 REQD
7R0014972-5 SHELL 1 REQD
7R0014969-5 INLET 1 REQD
7R0014972-17 FLANGE 1 REQD
2 X .20 SEALING SURFACE
18 X R .12
2 X R .12
(12) ALLOWABLE ALTERNATE: RB0170-125
(11) HOLE ROTATED INTO VIEW
(10) CRITICAL REQMT-TO BE VERIFIED BY QUALITY ASSURANCE
9 △ SYMBOL INDICATES WELD JOINT IDENTIFICATION
8 INSTALL FITTINGS AND TUBE ASSYS PER RA0102-005
(7) DRY FILM LUBE PER RA0110-003 TYPE 1, THREADS ONLY
(6) FLATNESS AND WAVINESS MAY DEVIATE AT THE RATE OF .0003 INCHES PER INCH CIRCUMFERENTIALLY AND .0020 INCHES PER INCH RADIALLY
(5) SHALL BE FREE OF NICKS, SCRATCHES OR OTHER IMPERFETIONS WHICH WOULD IMPAIR ITS SEALING FUNCTION
(4) DEEP ELECTROCHEMICAL ETCH IDENTIFY PER RA0104-008
(3) GTA WELD PER RA0107-027 CL 1
2 PENETRANT INSPECT DASH NO PART PER RA0115-116
1 MACHINE PER RA0103-002
NOTE: UNLESS OTHERWISE SPECIFIED
FOR INFORMATION
-3 | ALLOY 625 BAR | | AMS5666 (12)
NO | MATERIAL | SIZE | SPECIFICATION
PG 138
Rockwell International Corporation
Rocketdyne Division
Canoga Park, California
DWN H. DUBRICK
DSGN H. DUBRICK R. BAILY
DESIGN ACTIVITY APVD G. LOBERE
MANIFOLD-FUEL, EXPANDER CYCLE, COMB. CHAMBER, ASSY OF
SIZE J FSCM NO 02602 DWG NO 7R0016279
SCALE 2/1
DO NOT SCALE PRINT
7R0016279

Report Documentation Page

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7. Authors William S. Brown		8. Performing Organization Report No. RI/RD 91-235
9. Performing Organization Name and Address Rockwell International Rocketdyne Division 6633 Canoga Avenue Canoga Park, CA 91304		10. Work Unit No. 11. Contract or Grant No. NAS 3-23773
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15. Supplementary Notes

Program Manager, G. P. Richter, NASA Lewis Research Center, Cleveland, OH

Technical Manager, S. H. Morren, NASA Lewis Research Center, Cleveland, OH

16. Abstract

In order to increase the performance of a high performance, advanced expander-cycle engine combustor, higher chamber pressures are required. In order to increase chamber pressure, more heat energy is required to be transferred to the combustor coolant circuit fluid which drives the turbomachinery. This requirement was fulfilled by increasing the area exposed to the hot-gas by using combustor ribs. A previous technology task conducted 2-d hot air and cold flow tests to determine an optimum rib height and configuration. In task C.5 a combustor calorimeter was fabricated with the optimum rib configuration, 0.040 in. high ribs, in order to determine their enhancing capability. A secondary objective was to determine the effects of mixture ratio changers on the enhancement during hot-fire testing. The program used the Rocketdyne Integrated Component Evaluator (ICE) reconfigured into a thrust chamber only mode. The test results were extrapolated to give a projected enhancement from the ribs for a 16 in. long cylindrical combustor at 15Klb nominal thrust level. The hot-gas wall ribs resulted in a 58% increase in heat transfer. When projected to a full size 15K combustor, it becomes a 46% increase. The results of those tests, a comparison with previous 2-d results, the effects of mixture ratio and combustion gas flow on the ribs and the potential ramifications for expander cycle combustors are detailed.

17. Key Words (Suggested by Author(s)) Enhanced Heat Transfer Combustor, Ribbed Combustor, Hot-Gas Wall Ribs, Heat Transfer Enhancement		18. Distribution Statement Unclassified - Unlimited	
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No. of pages	22. Price*

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